PREDICTION OF CALLS FOR EMERGENCY AMBULANCE SERVICE

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PREDICTION OF CALLS FOR EMERGENCY AMBULANCE SERVICE

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SUMMARY

Although various features of emergency ambulance systems have been fairly intensively studied during recent years, the nature of the demand for such services still remains relatively uninvestigated. The lack of knowledge of the basic characteristics of such demand clearly compounds the problem of formulating plans for ambulance service facilities regarding their capacities, locations and types of services. In particular, it would be desirable to possess accurate quantitative models relating the demand for treatment of medical emergencies in a community to its socio-economic characteristics, demographic characteristics, land use and traffic characteristics, etc. Such models would be desirous for total demand as well as for the demand by different categories of medical emergencies.

The purpose of this research was to develop such a model based upon ambulance demand data extracted from the records of a large metropolitan hospital in Atlanta, Georgia. The formulation of this model specifically emphasized the use of exogenous variables whose values were derived during the same period as the endogenous variables and also the relative importance of each exogenous variable in terms of its contribution to the variation in each classification of ambulance calls. Additionally, in cases where the first-order linear models did not give appropriate fit to the empirical data, second-order linear models were formulated.

The results of this research showed that both the first and second-order models that were developed provided a good deal of new information about the basic nature of the demand for emergency ambulance service in a not untypical urban area. Such information should be useful for the evaluation of existing emergency medical systems and for future planning of capacity requirements and optimal locating of ambulance and emergency treatment facilities.

CHAPTER I

INTRODUCTION

Background

With over 1.9 million deaths and 10 million disabling injuries per year,[21] any research in the overall area of emergency health care must eventually focus upon the transportation of persons to emergency medical facilities or the transportation of medical care to the patient. In either case, the primary means of transportation in emergency situations is the ambulance. Since the ambulance is the major link between the patient in an acute trauma or medical situation and effective medical care, it is imperative that medical system planners and administrators study both the actual demand for emergency service and the reasons for the demand.

Under ideal circumstances, city planners would like to be able to predict with great accuracy all calls for emergency service and their frequencies and types. Armed with this information, emergency medical system planners would be able to locate properly equipped and properly staffed emergency vehicles in positions such that delays between the onset of the symptoms and arrival of the care would be minimized within realistic budget constraints. Additionally, such information forecasted well into the future would provide an invaluable data base upon which future operational and fiscal requirements could be based. The ultimate objective of this type of planning and forecasting would be to provide the best possible emergency medical service for all of the citizens of a given geographical area.

Literature Survey

One of the first studies which addressed itself, in part, to the prediction of emergency ambulance call rates was the 1968 report entitled "Economics of Highway Emergency Ambulance Services."[20] This study included a graph of the annual number of emergency ambulance calls generated from populations of given geographical areas. The information was based upon a survey of approximately 80 ambulance services. The resultant information yielded the following formulae:

$$Y = \begin{cases} 10.06X + 70 & \text{for } X \geq 10 & \text{(1a)} \\ 17.307X & \text{for } X < 10 & \text{(1b)} \end{cases}$$

where Y is the number of emergency calls per year and X is the population($x10^{-3}$) of the service area. On the basis of a sample of size 80, the correlation coefficient between Y and X for Eq. (1a) and (1b), respectively, was estimated as $r = 0.71$ and $r = 0.83$. The standard error for the estimate of the slope of the regression line was found to be 1.48 and 1.5 for Eq. (1a) and (1b), respectively.

Further analysis of 10 additional ambulance services by Stevenson (1971)[27] yielded an estimate of 35 emergency ambulance patients per 1000 population per annum. Table 1 illustrates the accuracy of the two prediction methods applied against real data.

Table 1. Comparison of Prediction Methods[10]

Location	Pop. ($x10^{-3}$)	Actual Calls	Equation 1a	Stevenson
Atlanta, Ga.	1,484	76,000**	14,910	51,940
Columbus, Ohio	600	25,226	6,106	21,000
Houston, Tex.	1,233	47,100	12,473	43,155
Jacksonville, Fla.	529	19,300	5,391	18,515

**Calls based upon estimates of emergency traffic and not actual records. This problem will be addressed separately in Chapter II.

It can be seen that Stevenson's estimates are the more accurate of the two sets of estimates. However, neither of the methods yield information pertaining to the location or the type of demand for emergency service for a given area.

A recent study by Aldrich, et al. (1971)[1] attempted to estimate the nature of the demand for emergency ambulance service using the records of a public emergency ambulance system. Calls for ambulance service were tested as linear functions of some 26 exogenous variables which were derived primarily from the reports of the 1960 Decennial Census taken by the US Bureau of the Census. Total calls for the service were extracted from ambulance records for the city of Los Angeles for the period 1964 to 1967 and categorized into calls concerning automobile accidents, other accidents, cardiac, poisonings, other illnesses, and dry runs. The major conclusion of this study was that "demand for public ambulance service appears to be highly predictable, using a simple linear model employing socio-economic variables, quality of service variables, and land use variables."[1] The primary shortcomings of this study were the following:

1. The study used exogenous variables which were derived primarily in 1960 to explain population related responses during the period 1964 to 1967.

2. The study settled for only fair coefficients of multiple determination for models involving sub-classifications of calls and there was apparently no attempt to test alternative models.

3. The study did not discuss the problems of multicollinearity, i.e., correlation among the independent variables.

4. There was no discussion of the relative importance of each of the independent variables in terms of their contribution to each of the dependent variables.

Another study by Gibson, et al. (1971)[14] also attempted to analyze the demand for emergency ambulance service by utilizing ambulance records maintained in the Chicago area. Gibson was able to reduce the number of regressors in his linear model to three (age, income and M.D.'s per 1000 population) and still maintain an $R^2 = 0.89$ for total utilization of emergency ambulance service. As with Aldrich's investigation, this study also used 1960 demographic data as regressors for emergency ambulance service calls which were received in Chicago during 1969. Additionally, Gibson did not investigate the relative importance of his exogenous variables nor did he discuss multicollinearity problems.

Other research in the area of socio-economic factors included a two-week study of emergency patients at a large public hospital in 1965.[35] This study of 2,028 patients concluded that the average user of this facility was primarily migratory, relatively poor and a member of a minority group. Another study in 1968[37] for a different hospital surveyed 3,058 patients and concluded that low socio-economic factors such a low income families, low education, low socio-economic occupations, and high residence mobility appeared to be the primary characteristics of emergency facility users. Both of these studies showed the importance and relevance of socio-economic indicators as explanatory factors for users of emergency rooms and emergency facilities. Additionally, socio-economic factors have been used in the prediction of crime and crime rates and the impact of public policy on crime. A study in 1970[34] used regression analysis in an attempt to describe the incidence of crime as a function of such variables as population, family income, education, and other socio-economic factors. Another study in 1972 attempted to determine public policy impact on crime deterrence. This study also used regression analysis and such socio-economic explanatory factors as per capita anti-poverty expenditures, per capita expenditures for local schools, and number of low-rent public houses per 1000 occupied housing units among other crime-related variables.

Objectives and Methodology of the Present Study

With the above background in mind, the objective of the present research was to determine the social, economic, land-use and transportation factors by which the call rate for emergency ambulance service for a given geographical area of a metropolitan region is affected and may be predicted. The total call rate was investigated and was itself deliniated into meaningful medical and operational sub-categories.

Specific emphasis was placed upon the following topics:

1. This research used values of exogenous variables which were derived during the same period as the endogenous variables.

2. The study considered and analyzed the relative importance of each exogenous variable in terms of its contribution to the variation in each classification of ambulance calls.

3. This research considered categories of emergencies different from those previously analyzed.

4. In cases where first-order linear models did not give appropriate fit to the empirical data, second-order linear models were formulated.

The methodology employed by this research entailed firstly selecting the base month for the collection of ambulance calls. Due to the fact that the primary source of data, the publications of the US Bureau of the Census, had an effective date of 1 April 1970, the month of March 1970 was selected as the base month. Additionally, considering the yearly cyclic variation of calls, March was a good month since its call rate was determined to be approximately equal to the average monthly call rate for that fiscal year period. Dependent variables were then drawn from available ambulance records and independent variables were extracted from US census data and information obtained from local and state governmental agencies. Linear statistical demand models were initially hypothesized and then the parameters estimated by least squares regression. Actual calculations were conducted by the U.C.L.A. BIO-MED Stepwise Regression Program which according to its description:

> computes a sequence of multiple linear regression equations in a stepwise manner. At each step one variable is added to the regression equation. The variable added is the one which makes the greatest reduction in error sum of squares. Equivalently it is the variable which has the highest partial correlation with the dependent variable partialed on the variables which have already been added; and equivalently it is the variable which, if it were added, would have the highest F value.[5]

Second-order models were also formulated and tested using the same program.

The simplest basic model and the first one to be tested was a first-order linear statistical model that was somewhat similar to that used by some earlier investigators[1,14] which, as far as the author is aware, are the only two demand models for emergency ambulance service that have been formulated and tested to date. This model relates the demand or call rate for emergency ambulance service per capita to exogenous variables associated with population characteristics X_{1j}, economic characteristics X_{2j}, geographic and land-use characteristics X_{3j}, and transportation characteristics X_{4j}. A description of these variables is given in Chapter II and Table 3. Thus, the basic model was

$$Y_i = B_{i0} + \sum_{j=1}^{12} B_{ij}^1 X_{1j} + \sum_{j=1}^{6} B_{ij}^2 X_{2j} + \sum_{j=1}^{10} B_{ij}^3 X_{3j} + \sum_{j=1}^{6} B_{ij}^4 X_{4j} \quad (2)$$
$$+ \epsilon_i$$

where the subscript i refers to the i^{th} type or category of medical emergencies; the B_{ij}^k are the unknown constant parameters to be estimated and ϵ_i is the error term.

In addition to the f rst-order models of Eq. (2) for $i = 1,2,\ldots,8$, second-order linear models without interaction terms were also formulated for the eight endogenous variables.

CHAPTER II

DATA BASE

Background

As stated in Chapter I, the major objective of this study was to determine the factors by which calls for emergency ambulance service may be predicted. The data requirements for solution of this problem, therefore, centered about two areas:

1. The determination of the call rate for emergency ambulance service during a period of specified length.

2. The measurement of all possible factors which may have influenced the emergency call rate during that period.

The most comprehensive source of data for influencing factors was the Decennial Census taken by the U. S. Bureau of the Census in 1970. Such factors were measured through "in-the-field" surveys by Bureau personnel and also through enumeration reports mailed to the Bureau by selected private citizen respondents (see Appendix A, Census Data, for additional information). Before these factors are discussed in any detail, however, a description of the ambulance and ambulance records status for Metro-Atlanta in 1970 will be given.

A report released by the Atlanta Regional Commission in 1973 revealed that during 1972 there existed over 65 different ambulance firms in the five county area surrounding Atlanta known as the Atlanta Standard Metropolitan Statistical Area (SMSA). These firms were either separate ambulance services on specialized functions within local funeral homes. Of the 65 ambulance firms, 41 claimed to provide emergency service, the rest providing only convalescent transportation.[4] Since neither official legislation nor a regionally coordinated emergency medical system existed, these services were not required to maintain any records of their responses to calls for emergency ambulance service. In fact, a survey of 18 ambulance firms in the Metro Area revealed that only two firms maintained usable historical records. Hence, information for the data-base month was predicated upon the existence of a historical file of emergency and non-emergency ambulance calls which was maintained by the ambulance department of Grady Memorial Hospital of Atlanta.

Grady Memorial Hospital is owned and operated by the Fulton-DeKalb Hospital Authority, a corporate organization of the State of Georgia. During 1970, Grady Hospital was the primary facility in the Atlanta area for providing treatment to persons requiring emergency medical care. During the base period, Grady's Ambulance Department had nine emergency vehicles in operation and provided service on a 24 hour-per-day basis.[19] Due to both the size of the hospital and the ambulance department in comparison to other facilities in the Atlanta SMSA and an "in the field" survey, the Atlanta Regional Commission estimated that Grady accounted for over 57% of the responses to emergency calls within the Metro area during 1972. Private communication with personnel at Grady Hospital revealed that the percentage of service for the base period in 1970 was approximately the same.[6,11] It should also be noted that while Grady was the most active provider of emergency service in the Atlanta SMSA, the seven most active providers of emergency service accounted for over 83% of the total emergency runs in 1972.[4]

The Ambulance Department at Grady operates under two important policies which were also in effect during the base period of March 1970 and which should be explained at this time. Firstly, all incoming calls of an emergency nature are serviced by the department and no screening of any type is conducted by the ambulance dispatcher. This policy was important to the study since the dispatch records accordingly reflected not only calls of a true emergency nature but also calls which were perceived by a given population as being of an emergency nature. In essence, this unscreened or unfiltered system revealed actual responses for selected areas which was extremely important for prediction purposes.

Secondly, in the event that all of Grady's ambulances were committed, the nearest private ambulance firm to the emergency was asked to respond to the call. Agreements with the firms stipulated that Grady Hospital would reimburse the private firm a fixed amount per back-up run, thereby relieving the firm of fee collection responsibilities. This policy was particularly important to the present study in two respects;

1. All calls of a back-up nature were recorded by the ambulance dispatcher in a log book, and under the agreement with the private firms, after completion of the run, the private firm was required to complete a "Record of Outside Call," an administrative report, which was processed within the hospital in a manner similar to Grady's own reports.

2. In areas of the city where average income levels of callers were extremely low, fee collection for private ambulance firms was a

critical problem. Therefore, upon receipt of a call for service directly from a private citizen, many private firms called Grady Hospital to obtain permission to respond to the call thereby insuring eventual payment for the service.[11]

Therefore, even though there were competing services within the same area, the records at Grady revealed a high degree of information regarding emergency calls from a given area. During 1969, while Grady Hospital responded to over 24,300 emergency calls, the hospital also paid for a total of 1,350 private ambulance back-up calls reflecting 5.2% of the total calls serviced during that period.[28]

Since records did not exist for all firms which provided service in the Atlanta SMSA, the initial problem for this research became one of determining an area of Atlanta for which approximately all emergency calls could be obtained. Through discussions with ambulance personnel, a 79 census tract area of operations for Grady Hospital was selected (see Appendix A, Figure 1). A subsequent survey conducted by the author revealed that of the 17 private ambulance firms located within or immediately adjacent to the area of operations, 14 firms provided very limited emergency service during the base period (less than five calls per month). Of the remaining three firms, one firm was located in Southeast Atlanta and maintained a historical file similar to Grady's. An investigation of its records revealed that this firm responded to a total of 49 emergency calls during the base period, three of which were located in the 79 tract area of operations. Since these calls were documented, they were included in the present study. The second private firm was located a short distance north of the area of operations and was the second largest provider in the SMSA. This firm did not, however, maintain any usable records reflecting their responses during 1970. The third firm was located in the northwest section of the area of operations but also did not maintain usable service records for the 1970 period. Discussions with the owner of one of these firms and a records clerk of the other firm revealed that the two firms accounted for an approximate total of 50 emergency calls within the 79 tract area of operations during the base period. Of this number of calls, 26 were documented in Grady's files as private ambulance back-up calls. The remaining approximate 24 calls were not documented or located and, based upon discussions, were assumed to be randomly dispersed throughout the area of operations but were not used in the analysis.[22] Additionally, the larger of these two firms was surveyed in 1970 by the Metropolitan Atlanta Council for Health Services, at which time the firm reported that the majority of its calls during 1969-1970 were of a private back-up nature in support of Grady Hospital.[19] In conclusion, the survey revealed that the 79 tract area of operations was an appropriate selection and that Grady's records reflected an estimated 98% of the total emergency calls that originated from that area.

Endogenous Variables

As mentioned in Chapter I, the endogenous or dependent variables for this study were emergency ambulance calls. Before a detailed description of these variables is given, however, it is desirable that Grady's operational procedure be discussed.

Incoming calls to Grady Hospital during the base period were received by an ambulance department dispatcher located in a room adjacent to the ambulance personnel waiting room. Upon receipt of a call, the dispatcher initiated a standardized form entitled "Report of Outside Call" which included name, address, and the coded complaint of the patient. Typical would be a person down(67), person injured(47), or an automobile accident(41). The form was then handed to a driver/emergency technician (EMT) team who then immediately responded to the call. Once a run was completed, appropriate sections of the report were completed by the EMT and the form was returned to the dispatcher who then entered a summary record of the run in a dispatch log book. The report was then processed within the hospital and included one copy for the ambulance department which was used for vehicle/personnel utilization records and then destroyed; one copy for the hospital administration which was filed for approximately two years and then destroyed; and one copy for the hospital billing department which after financial processing was filed permanently. After a dispatcher's log book, which contained the summary records, was completed, the book was maintained by the ambulance department in the Director's Office in the historical file which included records from August, 1966, to March, 1973.[11]

All calls received by Grady during the base period were initially extracted from the appropriate log books. These calls were then located by Census Tracts using either a census tract-street index, or in the case of street intersections, by plotting the call using the map series found in the Atlanta City Block Statistics.[32] After locating each call, the "Report of Outside Call" for each run was investigated and the following information, when available, was recorded: police call code; age/sex/

race of the patient; location of the patient (street, apartment, etc.); address and census tract of the call (crossed checked with the dispatcher's log books); condition of the patient at the scene; and the final disposition of the call or the final destination of the patient. See Appendix B for an example of a completed "Report of Outside Call." Results of this phase showed that Grady responded to a total of 2,446 emergency calls during the base period, including 91 private ambulance back-up calls, of which 1,857 calls or 75% of the calls were located in the 79 tract service area. The remaining 25% of the total calls were dispersed throughout the SMSA, primarily in the remaining sections of Fulton and DeKalb Counties.

It is perhaps appropriate at this time to discuss a problem encountered through the use of the "Reports of Outside Calls." Other than major obvious injuries such as cuts, fractures, gunshot wounds, etc., the actual condition of the patient was subject to both interpretation of vital signs and also the credibility of the patient's own complaints. Interviews with ambulance personnel revealed that in cases that included such complaints as stomach or chest pains or severe headaches were difficult to substantiate but were listed on the form as stated by the patient. An unestimated number of emergency calls for such types of complaints were felt by hospital personnel to be basically unwarranted or false and were used only as a means of obtaining transportation to both the hospital and in some cases to the downtown area. Even in cases where the patient was seen in one of the emergency rooms and a clinical record of the visit established, legal obstacles precluded an investigation of the files to determine whether or not the condition of the patient was such that an emergency run was necessary. Such suspected false calls, however, were not considered by hospital personnel to be a significant category of calls. Therefore, the present study assumed that the patient's complaint and condition section of the "Report of Outside Call" was accurate for all calls.[6,11]

During the tabulation of the emergency calls, it was recognized that calls for emergency service tended to show certain similarities in the sense that patient's complaints and injuries could be easily grouped into major medical categories. Further, discussions with the Chief EMT and the Senior Resident Doctors for the Surgical and Medical Emergency Clinics at Grady Hospital indicated that classification of calls was feasible and appropriate particularly for the simplification of EMT training.[6] For example, if a category of fractured limbs could be predicted quite accurately, special emphasis in the treatment of fractures in EMT training could be given and, additionally, the ambulances destined to serve such calls could be equipped with the proper medical treatment equipment. With this rationale in mind, an analysis of the patient's complaints and conditions was conducted and the following categories resulted:

1. TOTAL CALLS: As previously described, this number reflected the total recorded number of calls for a given census tract without regard to any of the specific aspects or nature of the calls.

2. DRUG INTOXICATION: This category included primarily three major types of drug usage: alcohol intoxication; both inadvertent drug overdoses, such as a child eating aspirin and drug overdoses of a suspected suicidal nature; and drug overdoses of chemicals of a so-called

pleasure producing nature such as heroin, barbituates, etc.

3. OBSTETRICS/GYNECOLOGY: This category included pre-delivery and delivery problems and some female complaints all of which were easily diagnosed and categorized by the EMTs. These females were normally taken to the Obstetrics Emergency Clinic at Grady Hospital.

4. AUTOMOBILE-RELATED TRAUMA: This category was called automobile-related since it included calls both for persons injured in automobile accidents plus persons injured when struck by an automobile. Trauma as used here covered the entire spectrum of specific injuries including fractured limbs; lacerations, contusions, as well as bodily injuries such as those to the chest and head. Shock was also considered within the current category.

5. OTHER TRAUMA: This category covered a variety of trauma related calls including persons shot; persons stabbed; other violence related injuries such as beatings; persons injured including fractured limbs, cuts and burns; and internal injuries for various reasons sometimes not specified on the Report and assumed to be primarily non-violence related. Also included in this category were calls from persons complaining of pain, primarily abdominal.

6. CARDIO-VASCULAR AND PULMONARY: This category was for calls that included heart attacks and categories of general heart disease and pain; strokes; high blood pressure and chest pains; and respiratory problems such as asthma and pneumonia.

7. OTHER MEDICAL: This category included all medical problems not covered by any of the previous variables such as persons who were sick or ill, psychiatric problems, persons who had fainted or were

discovered unconscious, and also persons who died for reasons not related to any of the previous categories, such as the discovery of a deceased person who was neither shot to death nor died in an auto accident.

8. DRY RUNS: This category of calls included all responses to calls where either the patient was not at the scene upon arrival of the ambulance (gone upon arrival); when the person at the given address did not call for an ambulance (false call); or the person injured for any reason refused to be treated by the ambulance crew and taken to a hospital (refused). All calls which resulted in a cancellation enroute because either the police department or a private ambulance also responded and handled the call, were classified under the appropriate category when sufficient information was given. For example, in the case where the police called in a Code 51-4, i.e., "person shot, ambulance required," and Grady responded, but the call was either cancelled enroute or at the scene because the police or a private ambulance transported the patient to the hospital, the call would be recorded as an "other trauma" even though Grady technically had a "dry run." This type of classification flexibility made it possible to measure true responses and acknowledge the fact that a call was made and answered even though one firm did, in fact, have a "dry run."

A final possible category of convalescent or transportation runs should be mentioned at this time. This category of calls was a fairly significant category for Grady's ambulance department. However, insofar as prediction of these non-emergency calls is concerned, the data base records at Grady reflect a reversal of the situation surrounding emergency calls. As a general policy guideline, Grady devoted a portion of its time and vehicle utilization to transportation calls, but for the most part placed upper bound restrictions on the number of responses and tended to force callers to the nearest private ambulance service.[11] Even though the primary source of revenue for all private ambulance firms is in the transporting of persons to and from their homes, doctor's offices and hospitals, the lack of data as described previously precluded investigation of this type of call. Additional information on code 82 calls received by Grady Hospital is given in Appendix E. Table 2 summarizes the results of categorization of calls for all census tracts in the area of operation in accordance with the above discussion. Appendix C, Table 17, listed the per capita values of the endogenous variables on a per census tract basis.

Table 2. Endogenous Variables

Variable	Mean ($x10^4$)	Standard Deviation	Description
Y_1, Total Calls	88.97	144.79	Total number of calls per capita per census tract without regard to their nature
Y_2, Drug Intoxication	6.44	21.50	Number of calls per capita arising from drug related incidents
Y_3, OB/GYN	3.34	4.99	Number of calls per capita involving obstetrics or gynecology
Y_4, Auto-related trauma	8.25	14.12	Number of calls per capita arising from auto and auto-related accidents
Y_5, Other trauma	21.82	42.03	Number of calls per capita involving non-auto-related trauma
Y_6, Cardio-vascular	9.29	16.14	Number of calls per capita involving cardio-vascular and pulmonary incidents

Table 2. (Continued)

Variable	Mean ($x10^4$)	Standard Deviation	Description
Y_7, Other medical	18.71	24.80	Number of calls per capita arising from medical reasons other than those covered by previous categories
Y_8, Dry Runs	22.95	36.38	Number of calls per capita that were either false, patient gone upon arrival of ambulance or patient refused treatment

Exogenous Variables

As mentioned previously, the values of the exogenous variables for this study were based primarily upon publications released by the Bureau of the Census in its 1970 Decennial Census reports. The overall set of exogenous variables incorporated into the models may essentially be grouped into the following four categories: population characteristics, economic characteristics, geographical and land-use characteristics, and transportation characteristics. The specific variables within each of these categories were selected primarily due to data availability, results of interviews with ambulance attendants and hospital personnel during which probable relationships were discussed, and also the previous research as described in Chapter I. Table 3 gives a summary of the variables considered. Appendix C gives a more detailed description of the derivation of certain of the variables and also the values of all of the exogenous variables on a per census tract basis.

Table 3. Exogenous Variables

Reference Name	Variable	Mean	Standard Deviation	Description
PC BLK	X_{11}	63.82	40.89	% of population which is Black
LT 15	X_{12}	27.39	9.62	% of population younger than 15 yrs.
GT 65	X_{13}	10.79	6.49	% of population older than 65 yrs.
AV AGE	X_{14}	31.78	5.40	Average age of the population
SGL M	X_{15}	48.49	12.39	% of male population (over 14 yrs) who are unmarried, separated, widowed or divorced
SGL F	X_{16}	58.92	12.13	% of female population (over 14 yrs) who are unmarried, separated, widowed or divorced.
PC SCH	X_{17}	27.42	8.51	% of age group 3 to 34 who are enrolled in school
YR SCH	X_{18}	9.86	1.57	Median school years completed by persons over 25 yrs old
RESTAB	X_{19}	43.51	14.07	% of the population who have lived in the same house since 1965
UNEM M	X_{110}	4.46	3.24	% of the male population who are unemployed
UNEM F	X_{111}	6.26	3.48	% of the female population who are unemployed
PC FEM	X_{112}	53.77	5.87	% of the population who are females
INC FA	X_{21}	63.32	22.99	Median income of all families during 1969($\times 10^{-2}$)
INC UN	X_{22}	24.58	11.49	Median income of all unrelated individuals in 1969($\times 10^{-2}$)
FA POV	X_{23}	24.90	16.49	% of families whose income in 1969 was less than a standardized poverty level

Table 3. (Continued)

Reference Name	Variable	Mean	Standard Deviation	Description
UN POV	X_{24}	46.05	15.59	% of unrelated individuals whose income in 1969 was less than a standardized poverty level
VALOW	X_{25}	12.35	4.41	Median value of all owner occupied housing units($x10^{-3}$)
RENT	X_{26}	72.29	20.27	Median contract rent of all renter occupied housing units
ACRES	X_{31}	46.83	73.31	Total tract acreage($x10^{-1}$)
ACR PC	X_{32}	11.31	8.13	Total tract acreage divided by tract population($x10^{2}$)
HSES	X_{33}	132.24	71.29	Total number of housing units($x10^{-1}$)
HSE PC	X_{34}	35.12	8.57	Total number of housing units divided by tract population($x10^{2}$)
PC OWN	X_{35}	28.90	21.98	% of housing units which are owner occupied
HS AGE	X_{36}	23.06	6.15	Average age of all housing units
PC OVC	X_{37}	15.43	8.16	% of all housing units with over one person per room
TR POP	X_{38}	14.08	56.63	Average number of persons temporarily residing in hotels and motels($x10^{-1}$)
PC COM	X_{39}	13.08	13.43	% of tract acreage in commercial use
PC IND	X_{310}	9.41	9.44	% of tract acreage in industrial use
WRK COM	X_{41}	97.52	88.01	Number of workers who either drive or ride as a passenger in an auto to work($x10^{-1}$)
AUTOS	X_{42}	23.94	12.88	Total number of autos divided by the population($x10^{2}$)

Table 3. (Continued)

Reference Name	Variable	Mean	Standard Deviation	Description
MLS XW	X_{43}	2.14	4.86	Mileage of expressways and freeways
MLS AR	X_{44}	10.98	8.29	Mileage of arterial routes
MLS CO	X_{45}	13.62	9.83	Mileage of collecter routes
MLS LC	X_{46}	45.64	34.14	Mileage of local routes

CHAPTER III

RESULTS AND DISCUSSION

Total Calls (Y_1)

Table 4 gives the least squares estimates obtained for the 34 parameters plus a constant using the first-order model for total calls. The coefficient of multiple determination was determined to be $R^2 = .93$ indicating a highly adequate fit for the data. The F statistic was 17.98 (the F statistic with 34 and 44 degrees of freedom must be greater than 2.2 for a level of confidence of 0.99) and the t-statistics (coefficient divided by its standard error) were as shown in the table. In determining the regressors which accounted for the greatest proportion of the variance in Y_1, the partial determination coefficient, R_k^2, was used. This coefficient was weighted with R^2 for the total original regression model and thus measured the relative contribution of the k^{th} regressor to Y_1 as

$$R_k^{*2} = R^2(100\%)\ R_k^2 / \sum_{i=1}^{34} R_i^2 .$$

An R_k^{*2} value of 4.0% was arbitrarily established by the author as a lower limit in determining which of the exogenous variables were significant contributors to the variation of the particular endogenous variable being considered. Therefore, all variables with $R_k^{*2} > 4.0$ were considered to be significant in all regressions involving Y_i for $i = 1,2,\ldots,8$.

Table 4. First-Order Models, All Call Categories

	Y_1(Total Calls)			Y_1(NO CBD)			Y_2(Drug intox.)		
Variable	$\hat{\beta}^k_{ij}$	t Stat	R^{*2}_{ij}(%)	$\hat{\beta}^k_{ij}$	t Stat	R^{*2}_{ij}(%)	$\hat{\beta}^k_{ij}$	t Stat	R^{*2}_{ij}(%)
PC BLK X_{11}	1.31	2.35	4.6	-0.27	-0.77	0.9	0.14	1.85	2.7
LT 15 X_{12}	5.67	1.47	1.9	1.27	0.54	0.5	1.05	2.03	3.3
GT 65 X_{13}	6.53	1.20	1.3	-2.61	-0.79	1.0	0.52	0.71	0.4
AV AGE X_{14}	8.10	0.76	0.5	3.44	0.53	0.4	1.67	1.17	1.2
SGL M X_{15}	1.28	0.63	0.4	2.00	1.70	4.3	0.14	0.50	0.2
SGL F X_{16}	-4.97	-1.67	2.5	-5.33	-3.00	11.8	0.16	-0.39	0.1
PC SCH X_{17}	-2.20	-1.06	1.0	-0.36	-0.30	0.1	-.32	-1.17	1.1
YR SCH X_{18}	11.31	0.79	0.6	13.16	1.65	4.1	1.87	0.98	0.8
RESTAB X_{19}	-0.12	-0.12	0.1	0.64	1.14	2.0	-0.03	-0.21	0.04
UNEM M X_{110}	7.78	2.56	5.4	-2.07	-1.02	1.6	1.46	3.59	8.6
UNEM F X_{111}	3.17	1.22	1.4	1.43	0.92	1.3	0.49	1.40	1.6
PC FEM X_{112}	1.72	0.44	0.2	3.88	1.57	3.7	-0.24	-0.46	0.2
INC FA X_{21}	-3.08	-2.61	5.5	1.01	1.01	1.6	-0.63	-3.95	10.0
INC UN X_{22}	-1.32	-0.83	0.6	-0.11	-0.12	.02	-0.22	-1.06	0.9
FA POV X_{23}	0.88	0.57	0.3	0.93	1.00	1.6	-0.12	-0.57	0.3
UN POV X_{24}	0.41	0.29	0.1	1.50	1.91	5.4	-0.15	-0.79	0.5
VALOW X_{25}	6.66	1.95	3.3	3.15	1.63	4.0	0.47	1.03	0.9
RENT X_{26}	2.17	2.04	3.6	0.94	1.23	2.3	0.35	2.43	4.5
ACRES X_{31}	-1.26	-4.05	11.3	-0.20	-1.00	1.6	-0.13	-3.19	7.2
ACR PC X_{32}	10.85	5.28	16.1	0.52	0.33	0.2	1.16	4.21	10.9
HSES X_{33}	-0.86	-2.68	5.8	-0.20	-1.03	1.7	-0.16	-3.80	9.4
HSE PC X_{34}	-4.41	-1.58	2.2	1.88	1.10	1.9	-0.89	-2.40	4.4
PC OWN X_{35}	-2.78	-2.30	4.4	-1.00	-1.38	2.9	-0.34	-2.08	3.4
HS AGE X_{36}	4.76	1.98	3.4	1.88	1.33	2.7	0.53	1.64	2.2
PC OVC X_{37}	-0.97	-0.37	0.1	-0.03	0.02	0.001	-0.30	-0.86	0.6
TR POP X_{38}	0.64	1.96	3.3	0.00	0.00	0.0	0.11	2.53	4.8
PC COM X_{39}	1.93	2.10	3.8	0.55	1.03	1.7	0.19	1.56	2.0
PC IND X_{310}	-0.34	-0.40	0.2	0.07	0.16	0.1	-0.01	-0.08	0.01
WRKCOM X_{41}	0.97	2.60	5.5	0.05	0.23	0.1	0.15	3.08	6.7
AUTOS X_{42}	0.17	0.07	0.01	-5.48	-3.12	12.6	0.31	0.88	0.7
MLS XW X_{43}	1.45	0.54	0.3	1.61	1.08	1.8	0.16	0.44	0.2
MLS AR X_{44}	-0.66	-0.49	0.3	1.32	1.58	3.8	-0.23	-1.29	1.4
MLS CO X_{45}	1.87	1.57	2.2	0.66	0.98	1.5	0.19	1.21	1.2
MLS LC X_{46}	0.63	1.05	1.0	-0.14	-0.39	0.3	0.12	1.54	2.0
Constant	-481.28			-381.95			-51.88		
R^2		.93			.80			.95	

Table 4. (Continued)

Variable	Y_3(OB/GYN) $\hat{\beta}^k_{ij}$	$\underline{t}$ Stat	R^{*2}_{ij}(%)	Y_4 (Auto) $\hat{\beta}^k_{ij}$	$\underline{t}$ Stat	R^{*2}_{ij}(%)	Y_5 (Other trauma) $\hat{\beta}^k_{ij}$	$\underline{t}$ Stat	R^{*2}_{ij}(%)
PC BLK X_{11}	-0.03	-0.87	0.9	-0.02	-0.17	0.04	0.49	2.47	6.1
LT 15 X_{12}	0.06	0.21	0.1	0.69	1.03	1.2	0.92	0.67	0.5
GT 65 X_{13}	0.21	0.57	0.4	0.77	0.80	0.7	1.96	1.01	1.1
AV AGE X_{14}	-0.91	-1.25	1.8	0.12	0.06	0.01	2.19	0.58	3.8
SGL M X_{15}	-0.05	-0.35	0.2	0.42	1.21	1.6	0.31	0.43	0.2
SGL F X_{16}	0.34	1.66	3.1	-0.62	-1.20	1.6	-1.40	-1.31	1.9
PC SCH X_{17}	0.02	0.12	0.02	0.17	0.46	0.3	-1.21	-1.63	2.9
YR SCH X_{18}	-0.29	-0.30	0.1	3.05	1.22	1.7	2.28	0.45	0.2
RESTAB X_{19}	0.13	2.06	4.7	-0.03	-0.16	0.03	-0.39	-1.17	1.5
UNEM M X_{110}	-0.11	-0.55	0.4	0.05	0.10	0.01	3.62	3.34	10.1
UNEM F X_{111}	0.42	2.36	5.9	-0.02	-0.05	0.003	1.37	1.48	2.4
PC FEM X_{112}	-0.66	-2.48	6.5	1.39	2.04	4.4	0.67	0.48	0.3
INC FA X_{21}	-0.25	-3.15	9.8	0.12	0.60	0.4	-1.04	-2.46	6.1
INC UN X_{22}	0.08	0.77	0.7	0.05	0.17	0.03	-0.65	-1.14	1.4
FA POV X_{23}	-0.13	-1.27	1.9	-0.04	-0.16	0.03	0.59	1.07	1.3
UN POV X_{24}	0.05	0.55	3.7	-0.34	-1.38	2.1	0.04	0.08	0.01
VALOW X_{25}	0.20	0.87	0.9	0.15	0.25	0.07	2.10	1.73	3.2
RENT X_{26}	0.11	1.54	2.7	0.09	0.49	2.8	0.54	1.42	2.2
ACRES X_{31}	-0.04	-1.91	4.1	-0.24	-4.39	15.5	-0.32	-2.88	8.0
ACR PC X_{32}	0.26	1.88	4.0	1.16	3.23	9.7	2.87	3.91	12.9
HSES X_{33}	-0.01	-0.63	0.5	-0.07	-1.30	1.9	-0.26	-2.26	5.2
HSE PC X_{34}	0.41	2.14	5.0	-0.17	-0.36	0.1	-1.68	-1.69	3.0
PC OWN X_{35}	0.18	2.21	5.3	-0.16	-0.77	0.7	-0.80	-1.85	3.6
HS AGE X_{36}	0.11	0.64	0.5	1.16	2.77	7.5	0.75	0.88	0.9
PC OVC X_{37}	0.08	0.46	0.3	0.24	0.53	0.3	-0.05	-0.05	0.003
TR POP X_{38}	-0.03	-1.21	1.7	-0.01	-0.21	0.05	0.13	1.11	1.4
PC COM X_{39}	0.06	0.96	1.1	0.26	1.64	2.9	0.62	1.90	3.8
PC IND X_{310}	0.06	1.05	1.3	-0.23	-1.54	2.6	0.10	0.34	0.1
WRKCOM X_{41}	0.03	1.15	1.5	0.17	2.60	6.8	0.25	1.92	3.9
AUTOS X_{42}	-0.07	-0.37	0.2	-1.18	-2.60	6.8	1.07	1.15	1.5
MLS XW X_{43}	0.32	1.77	3.5	0.67	1.44	2.3	-0.05	0.05	0.003
MLS AR X_{44}	-0.12	-1.27	1.9	0.43	1.85	3.7	-0.15	-0.31	0.1
MLS CO X_{45}	0.10	1.26	1.9	0.35	1.71	3.1	0.50	1.18	1.5
MLS LC X_{46}	-0.03	-0.72	0.6	-0.03	-0.32	0.1	0.30	1.40	2.1
Constant	23.34			-125.56			-88.90		
R^2		.74			.78			.90	

Table 4. (Continued)

Variable	Y_6(Cardio-vas.) $\hat{\beta}^k_{ij}$	$\underline{t}$ Stat	R^{*2}_{ij}(%)	Y_7(Other medical) $\hat{\beta}^k_{ij}$	$\underline{t}$ Stat	R^{*2}_{ij}(%)	Y_8(Dry runs) $\hat{\beta}^k_{ij}$	$\underline{t}$ Stat	R^{*2}_{ij}(%)
PC BLK X_{11}	0.07	0.86	0.9	0.23	1.96	6.0	0.43	2.81	6.7
LT 15 X_{12}	1.12	1.94	4.1	1.49	1.82	5.3	0.71	0.63	0.4
GT 65 X_{13}	-0.52	-0.63	0.5	0.03	0.02	0.001	3.48	2.17	4.3
AV AGE X_{14}	3.85	2.40	6.1	2.87	1.28	2.7	-1.42	-0.45	0.2
SGL M X_{15}	0.27	0.88	0.9	0.32	0.76	1.0	0.003	0.01	0.00004
SGL F X_{16}	-1.21	-2.70	7.5	-0.69	-1.10	2.0	-0.96	-1.09	1.2
PC SCH X_{17}	0.001	0.004	0.00001	-0.38	-0.87	1.3	-0.42	-0.68	0.5
YR SCH X_{18}	4.59	2.14	5.0	2.36	0.78	1.0	-1.77	-0.42	0.2
RESTAB X_{19}	-0.07	-0.50	0.3	-0.11	-0.53	0.5	0.26	0.94	0.9
UNEM M X_{110}	-0.64	-1.40	2.2	1.21	1.88	5.6	2.03	2.26	4.6
UNEM F X_{111}	0.09	0.23	0.1	0.49	0.89	1.3	0.49	0.64	0.4
PC FEM X_{112}	0.81	1.38	2.2	-0.05	-0.06	0.01	-0.21	-0.19	0.03
INC FA X_{21}	-0.08	-0.47	0.3	-0.39	-1.54	3.8	-0.55	-1.58	2.4
INC UN X_{22}	0.02	0.07	0.01	-0.29	-0.87	1.3	-0.23	-0.50	0.2
FA POV X_{23}	0.42	1.80	3.6	-0.01	-0.03	0.001	0.29	0.65	0.4
UN POV X_{24}	0.17	0.80	0.8	0.39	1.31	2.8	0.17	0.40	0.2
VALOW X_{25}	0.56	1.10	1.4	0.06	0.08	0.01	2.56	2.56	5.7
RENT X_{26}	0.21	1.32	2.0	0.39	1.74	4.8	0.47	1.50	2.1
ACRES X_{31}	-0.13	-2.78	7.9	-0.13	-1.91	5.7	-0.37	-4.03	11.9
ACR PC X_{32}	1.09	3.51	11.5	1.39	3.19	14.1	3.22	5.32	17.3
HSES X_{33}	-0.05	-1.04	1.3	-0.17	-2.51	9.4	-0.17	-1.83	3.1
HSE PC X_{34}	-0.86	-2.06	4.6	0.05	0.08	0.01	-1.11	-1.35	1.8
PC OWN X_{35}	-0.50	-2.73	7.6	-0.38	-1.48	3.6	-0.77	-2.16	4.2
HS AGE X_{36}	0.47	1.29	1.9	0.78	1.54	3.8	1.48	2.09	4.0
PC OVC X_{37}	-0.05	-0.14	0.02	-0.09	-0.17	0.05	-0.51	-0.67	0.4
TR POP X_{38}	0.13	2.66	7.3	0.12	1.68	4.5	0.15	1.58	2.4
PC COM X_{39}	0.10	0.69	0.6	0.10	0.52	0.5	0.64	2.37	5.0
PC IND X_{310}	-0.03	-0.26	0.1	0.12	0.68	0.8	-0.36	-1.45	2.0
WRKCOM X_{41}	0.07	1.26	1.8	0.17	2.16	7.1	0.23	2.07	3.9
AUTOS X_{42}	-0.63	-1.61	3.0	-0.004	-0.01	0.0001	0.47	0.61	0.4
MLS XW X_{43}	-0.05	-0.11	0.02	-0.03	-0.05	0.01	0.25	0.32	0.1
MLS AR X_{44}	-0.04	-0.22	0.1	-0.01	-0.03	0.001	-0.15	-0.38	0.1
MLS CO X_{45}	0.19	1.07	1.3	0.16	0.65	0.7	0.67	1.91	3.4
MLS LC X_{46}	0.07	0.83	0.8	0.05	0.42	0.3	0.11	0.63	0.4
Constant	-168.58			-151.98			2.58		
R^2		.88			.90			.91	

As shown in Table 4, the most significant contributors were ACR PC(X_{32}), ACRES(X_{31}), HSES(X_{33}), INC FA(X_{21}), WRKCOM(X_{41}), UNEM M(X_{110}) and PC BLK(X_{11}), and these factors accounted for 54% of the total variation in Y_1. Of the significant variables, HSES(X_{33}) with a negative coefficient was opposite to that expected. It was originally felt that a straight measure of numbers of housing units per tract would have a positive effect upon total calls. The variable HSE PC(X_{34}), with a correlation of -.073 with HSES(X_{33}), also has a negative effect upon total calls which was expected and also cross-checks with Aldrich's Los Angeles Study. However, the author is unable to find any particular reason to support the coefficient for HSES(X_{33}). Additionally, neither Aldrich, et al. (1971),[1] nor Gibson, et al. (1971),[14] used this variable so that no comparison can be made directly.

As shown, this all variable model was highly significant and could be very beneficial from a planning viewpoint. However, from a practical viewpoint, this model requires too many variables for simplicity and ease of handling. Additionally, the costs involved in continuously gathering data on the 34 variables would probably preclude use of this model by planning departments with limited funds. Also, the number of variables increases and compounds problems associated with multicollinearity and the resultant precision of the estimates. With this rationale in mind, an attempt was made to reduce the number of explanatory variables while at the same time maintaining a significant fit to the data.

The best first-order results revealed a model using 14 explanatory variables with a resultant R^2 = .89 and an F statistic of 35.308. It was at this point of the research, however, that the goal of model simplicity was seen to be unrealistic using a first-order model. Therefore, a second-order model without interactions was formulated and tested.

Again using BIO-MED Stepwide Regression, the variable set was reduced to six explanatory variables with results as shown in Table 5. The coefficient of multiple determination was $R^2 = .90$ indicating a highly adequate fit for the data. The F statistic was 51.15 ($F_{.01;12,66} = 2.63$) and the individual t statistics were as shown in the table. The most important aspects of this model were simplicity of use and low costs for data gathering. These variables were considered to be easily measured and in the case of INC FA(X_{21}) easily estimated.

Table 5. Second-Order Model, Y_1

Variables Entered	Cumulative R^2	Final Step: Estimates $\hat{\beta}^k_{ij}$	Final Step: t Statistic	Final Step: R^{*2}_{ij}(%)
Constant term		10.58		
PC COM X^2_{39}	.45	0.15	5.29	18.9
UNEM M X^2_{110}	.69	2.07	6.41	24.4
INC FA X_{21}	.75	-5.05	-3.35	9.2
UNEM M X_{110}	.81	-16.16	-3.03	7.8
PC SCH X^2_{17}	.84	-0.18	-3.02	7.7
ACR PC X_{32}	.86	5.29	1.73	2.8
PC COM X_{39}	.88	-2.95	-2.17	4.2
INC FA X^2_{21}	.88	0.02	1.89	3.3
PC SCH X_{17}	.89	8.16	2.23	4.5
HSE PC X^2_{34}	.90	-0.14	-2.03	3.7
HSE PC X_{34}	.90	10.18	1.78	2.9
ACR PC X^2_{32}	.90	-0.07	-0.98	0.9

At this point of the study a comparison with the Chicago model was attempted.[14] The only different variable between the two studies was Chicago's "% of population less than 18 years old." The present study's variable was "% of population less than 15 years old," and it was felt that the difference between the two would be insignificant.

Table 6 gives the results obtained using the six variables and a first-order model. R^2 was determined to be 0.37 indicating an unacceptable fit to the data. The F statistic was 7.143 ($F_{.01;6,72} = 3.12$) and the individual t statistics were as shown in the table.

Table 6. Comparison of Atlanta and Chicago Studies

Variable	Chicago Study $\hat{\beta}^k_{ij}$ (t-stat.)	Atlanta Study First-Order $\hat{\beta}^k_{ij}$ (t-stat.)	Atlanta Study Second-Order $\hat{\beta}^k_{ij}$ (t-stat.)
Constant term	97.49	353.37	-32.21
PC BLK X_{11}	-0.25(-2.20)	-0.44(-0.87)	1.65(0.79)
X_{11}^2			-0.03(-1.44)
LT 15/18 X_{12}	0.44(0.80)	-3.91(-1.80)	7.64(1.02)
X_{12}^2			-0.26(-1.74)
YR SCH X_{18}	11.27(4.38)	17.67(1.29)	89.59(0.84)
X_{18}^2			-2.86(-0.52)
RESTAB X_{19}	-0.12(-0.42)	-1.58(-1.38)	5.68(0.96)
X_{19}^2			-0.07(-1.10)
INC FA X_{21}	-0.02(-7.48)	-4.01(-4.62)	-21.22(-6.24)
X_{21}^2			0.14(5.09)
PC OVC X_{37}	-1.54(-1.92)	1.23(0.40)	17.03(1.95)
X_{37}^2			-0.20(-0.87)
R^2	.66	.37	.61

Table 6 also gives the results obtained using the six variables and a second-order model. R^2 for this model was determined to be .61 showing a vast improvement over the first order model. The F statistic was 8.527 ($F_{.01;\ 12,66} = 2.63$) and the individual t statistics were as shown in the table.

It is interesting to note that in the first-order model the signs of the coefficients for LT 15(X_{12}) and PC OVC(X_{37}) were opposite to that of the Chicago study and also opposite to that obtained in the 34 variable case described earlier. The only reasonable explanation of this discrepancy probably centers either about the different sample sizes used by the two studies, the use of non-current independent variables by the Chicago Study, or other immeasurable differences between Chicago and Atlanta.

An attempt was also made to compare the present study to the results of the Los Angeles Study by Aldrich.[1] Eleven variables in the present study were equivalent to Aldrich's. An additional six variables were added - four transportation variables to replace Aldrich's % transportation land, % black for % white, and unemployed females - and one regression was run on total calls. Since an insufficient number of similar variables existed between the studies, a direct comparison was not possible. However, using the above mentioned 17 variables in a first-order model, an R^2 of .74 resulted which compared favorably with Aldrich's R^2 of .93 for 26 variables.

The final portion of the present study of total calls consisted of one regression with the Central Business District(CBD) tracts removed from the observations. The Central Business District is "an area of very high land valuation; an area characterized by a high concentration of retail businesses, offices, theaters, hotels, and "service" businesses; and an area of high traffic flow."[30] This run was felt necessary since the three tract CBD accounted for a high number of calls involving Drug Intoxication, other Trauma, and Dry Runs when compared to other tracts. Table 4 gives the least squares estimates obtained for the 34 parameters plus a constant using the first-order model for total calls. R^2 for this model was determined to be .80 indicating only a marginal fit to the data. The F statistic was 4.68 ($F_{.01;34,41} = 2.20$) and the t statistics were as shown in the table. Note that SGL M(X_{15}), SGL F(X_{16}), YR SCH(X_{18}), UN POV(X_{24}), and AUTOS(X_{42}) became the significant explanatory variables, while ACR PC(X_{32}), INC FA(X_{21}), and UNEM M(X_{110}) became relatively insignificant. While a shift in significant variables was expected, this result was surprising particularly since it was intuitively felt that INC FA(X_{21}) and ACR PC(X_{32}) would remain significant.

Drug Intoxication (Y_2)

Table 4 gives the least squares estimates obtained for the 34 parameters plus a constant using the first-order model for Drug Intoxication calls. The coefficient of multiple determination was determined to be $R^2 = .95$ indicating a highly adequate fit for the data. The F statistic was 22.44 ($F_{.01;34,44} = 2.2$) and the individual t-statistics were as shown in the table. The most significant variables in accounting for the variance in Y_2, ($R_k^{*2} > 4.0$), were ACR PC(X_{32}), INC FA(X_{21}), HSES(X_{33}), UNEM M(X_{110}), ACRES(X_{31}), WRKCOM(X_{41}), TR POP(X_{38}), RENT(X_{26}), and HSE PC(X_{34}). These variables accounted for over 57% of the variance in Y_2. Of the significant variables, HSES(X_{33}) and RENT(X_{26}) resulted with coefficient signs opposite to that expected. This result also occurred for total calls except that RENT(X_{26}) was less significant in that model. Again, there appears to be no reasonable explanation for this result. Additionally, these variables can not be compared to any previous studies.

Table 7 gives the least squares estimates for the second-order model using a reduced set of seven variables. R^2 for this model was determined to be .92 indicating a highly adequate fit for the data. The F statistic was 52.42 ($F_{.01;14,65} = 2.35$) and the individual t statistics were as shown in the table. The overall negative effect of FA POV(X_{23}) on Y_2 was interesting since excessive drug and alcohol usage are generally associated with the poorer areas of metropolitan areas. The Los Angeles Study did not have a drug intoxication category, per se, but used a poisoning category.[1] The variable FA POV(X_{23}) for this category in the Los Angeles Study had a positive coefficient. There appears to be no reasonable explanation for this result.

OB/GYN (Y_3)

Table 4 gives the least squares estimates obtained for the 34 parameters plus a constant using the first-order model for OB/GYN calls. The coefficient of multiple determination was determined to be $R^2 = .74$ indicating a relatively poor fit to the data. The F statistic was 3.600 ($F_{.01;34,44} = 2.2$) indicating an only marginally significant model in comparison to other results. The individual t statistics for each of the parameters were as shown in the table. The variables

Table 7. Second-Order Model, Y_2

Variables Entered	Cumulative R^2	Final Step		
		$\hat{\beta}^k_{ij}$	t Statistic	R^{*2}_{ij}(%)
Constant term		43.42		
PC COM X^2_{39}	.58	0.02	4.87	18.7
UNEM M X^2_{110}	.69	0.22	4.92	19.0
PC COM X_{39}	.76	-5.67	-2.80	7.5
INC FA X_{21}	.78	-1.52	-4.73	17.9
FA POV X_{23}	.82	-0.14	-0.40	0.2
INC FA X^2_{21}	.86	0.01	3.48	11.0
ACR PC X_{32}	.88	0.67	1.56	2.5
PC SCH X^2_{17}	.90	-0.01	-1.01	1.1
HSE PC X^2_{34}	.91	-0.02	-2.26	5.1
HSE PC X_{34}	.91	1.59	1.94	3.8
UNEM M X_{110}	.92	-1.15	-1.56	2.5
FA POV X^2_{23}	.92	-0.01	-1.34	1.9
ACR PC X^2_{32}	.92	-0.01	-0.75	0.6
PC SCH X_{17}	.92	0.24	0.40	0.2

INC FA(X_{21}), PC FEM(X_{112}), UNEM F(X_{111}), PC OWN(X_{35}), ACRES(X_{31}), HSE PC(X_{34}), and RESTAB(X_{19}) were the most significant contributors to the variance in Y_3 and accounted for 42% of the total variance. Highly surprising results of this model were the negative coefficient on PC FEM(X_{112}) and the positive coefficient PC OWN(X_{35}) both of which were felt to have been of opposite signs. However, in view of both the lack of an adequate fit to the data and the relatively low contribution of both of these factors to the total variation in Y_3, it was felt that these results were not serious for the first-order model.

Analysis of the second-order model also revealed some surprising results. Initial runs revealed that 41 first and second-order variables were required in the model to obtain an R^2 greater than 0.9. The results of the best reduced set included 15 variables and are shown in Table 8. R^2 for this model was determined to be .76 indicating again a relatively poor fit to the data. The F statistic was 4.97 ($F_{.01;30,48} = 2.03$) and indicated improvement in significance over the first-order model. The individual t statistics were as shown in the table.

The resultant coefficients for PC FEM(X_{112}) and PC OWN(X_{35}) had the same signs as the first-order model apparently indicating that either there existed a problem with the data base size or that possibly a model using interactions was required. There also existed the possibility that the proper factors were not being used. However, these problems notwithstanding, the second-order model did result in an improvement in the fit to the data while at the same time using less than 50% of the original variables.

Automobile-Related Trauma (Y_4)

Table 4 gives the least squares estimates obtained for the 34 parameters plus a constant using the first-order model for auto-related calls. The coefficient of multiple determination was determined to be $R^2 = .78$ indicating an only marginal fit to the data. The F statistic was 4.722 ($F_{.01,34,44} = 2.20$) also indicating only a marginally significant model in comparison to other results. The individual t statistics

Table 8. Second Order Model, Y_3

Variables Entered	Cumulative R^2	Final Step $\hat{\beta}^k_{ij}$	$\underline{t}$ Statistic	R^{*2}_{ij}(%)
Constant term		-12.98		
INC FA X_{21}	.26	-0.21	-0.72	0.9
ACR PC X_{32}	.42	0.23	0.97	1.7
PC FEM X^2_{112}	.50	-0.01	-0.86	1.3
INC FA X^2_{21}	.53	0.0002	0.11	0.02
UNEM F X_{111}	.55	0.93	1.65	4.5
RESTAB X^2_{19}	.57	-0.002	-0.68	0.8
RENT X_{26}	.61	0.12	0.60	0.7
PC OWN X^2_{35}	.63	0.002	1.66	4.8
PC IND X^2_{310}	.64	0.01	2.89	13.1
PC IND X_{310}	.68	-0.34	-2.53	10.4
PC OWN X_{35}	.69	-0.13	-0.98	1.7
RENT X^2_{26}	.70	0.00001	0.01	0.0002
MLS LC X^2_{46}	.71	-0.0002	-0.58	0.6
RESTAB X_{19}	.71	0.31	1.16	2.4
PC COM X_{39}	.72	0.21	1.54	4.2
PC COM X^2_{39}	.73	-0.003	-0.96	1.7
MLS LC X_{46}	.73	0.02	0.31	0.2
ACR PC X^2_{32}	.73	-0.001	-0.22	0.1
PC SCH X_{17}	.73	-0.72	-1.48	3.8
FA POV X^2_{23}	.73	0.002	0.44	0.4
FA POV X_{23}	.74	-0.06	-0.26	0.1
HSE PC X^2_{34}	.74	-0.01	-0.98	1.7
GT 65 X^2_{13}	.74	0.02	1.65	4.7
UNEM F X^2_{111}	.74	-0.04	-1.19	2.5
GT 65 X_{13}	.74	-0.60	-1.46	3.7
PC SCH X^2_{17}	.75	0.01	1.42	3.6
HSE PC X_{34}	.75	0.48	0.87	1.4
PC FEM X_{112}	.75	0.44	0.53	0.5
HS AGE X_{36}	.75	0.69	1.08	2.1
HS AGE X^2_{36}	.76	-0.02	-1.02	1.9

for each of the parameters were as shown in the table. The variables ACRES(X_{31}), ACR PC(X_{32}), HS AGE(X_{36}), AUTOS(X_{42}), WRKCOM(X_{41}), and PC FEM(X_{112}) were the most significant contributors ($R_i^{*2} > 4.0$) to the variance in Y_4 and accounted for 51% of the total variance. A highly surprising result of the model was the negative coefficient on AUTOS (X_{42}). However, auto-related trauma calls in a given tract are not necessarily all caused by the persons residing within the tract. In fact, a large number of calls for this study occurred in both tracts centered about the Central Business District and also on major arterial and collector routes which are used primarily for traffic movement by persons not necessarily residing in the immediate area. Note that the four classifications of routes for each tract accounted for over 10% of the total variation in Y_4.

A comparison to the Los Angeles study[1] results with its category of "auto accidents" reveals some major differences due in part to the fact that the present study considers auto-related trauma, a broader category. For example, LT 15(X_{12}) in the Los Angeles study had a negative coefficient which is intuitive because of driver-age restrictions. In the present study, the coefficient was positive and $R^{*2}_{LT\ 15} = 1.2$ indicating a positive influence on auto-related trauma incidents. This result was also highly intuitive since the majority of persons struck by automobiles are in both the very young and also the very old age brackets.[21]

Initial runs of the second-order model revealed that 30 first and second-order terms were required to obtain an R^2 greater than 0.9. The results of the best reduced set included 15 variables and are shown in Table 9. R^2 for this model was .85 indicating an adequate fit for

Table 9. Second-Order Model, Y_4

Variables Entered	Cumulative R^2	Final Step $\hat{\beta}^k_{ij}$	$\underline{t}$ Statistic	$R^{*2}_{ij}(\%)$
Constant		-124.12		
UNEM M X^2_{110}	.25	0.23	3.13	5.5
PC COM X^2_{39}	.43	0.01	1.58	1.6
UNEM M X_{110}	.48	-2.66	-2.36	3.4
AUTOS X^2_{42}	.51	-0.004	-0.48	0.2
RENT X_{26}	.54	0.80	2.48	3.7
SGL M X^2_{15}	.57	-0.01	-2.57	4.0
AUTOS X_{42}	.60	-0.76	-1.48	1.4
PC IND X_{310}	.62	-0.05	-0.15	0.02
MLS AR X_{44}	.64	0.27	0.60	0.2
HS AGE X_{36}	.67	4.85	2.85	4.7
HS AGE X^2_{36}	.69	-0.10	-2.60	4.0
TR POP X_{38}	.70	-0.01	-0.06	0.003
ACR PC X_{32}	.70	0.23	0.38	0.1
PC SCH X_{18}	.71	8.48	0.81	0.4
PC BLK X_{11}	.71	-0.36	-1.98	2.5
PC BLK X^2_{11}	.72	0.003	1.74	1.9
SGL M X_{15}	.73	1.001	2.20	3.0
MLS AR X^2_{44}	.74	-0.001	-0.06	0.003
RENT X^2_{26}	.74	-0.003	-1.80	2.1
WRKCOM X^2_{41}	.74	0.001	5.32	12.1
MLS XW X^2_{43}	.76	-0.24	-5.61	12.9
MLS XW X_{43}	.79	2.77	4.75	10.5
WRKCOM X_{41}	.84	-0.26	-4.43	9.5
PC COM X_{39}	.85	-0.39	-1.13	0.9
PC SCH X^2_{18}	.85	-0.31	-0.56	0.2
ACR PC X^2_{32}	.85	0.002	0.13	0.01
TR POP X^2_{38}	.85	-0.0001	-0.21	0.03
PC IND X^2_{310}	.85	-0.001	-0.16	0.02
LT 15 X_{12}	.85	0.24	0.29	0.1
LT 15 X^2_{12}	.85	-0.004	-0.29	0.1

the data. The F statistic was 9.094 ($F_{.01,30,48} = 2.10$) and the $\underline{t}$ statistics were as shown in the table.

Other Trauma (Y_5)

Table 4 gives the least squares estimates obtained for the 34 parameters plus a constant using the first-order model for other trauma calls. The coefficient of multiple determination was determined to be $R^2 = .90$ indicating an adequate fit to the data. The F statistic was 11.47 ($F_{.01,34,44} = 2.2$) and the $\underline{t}$ statistics were as shown in the table. The variables ACR PC(X_{32}), UNEM M(X_{110}), ACRES(X_{31}), PC BLK(X_{11}), INC FA(X_{21}), and HSES(X_{33}) were the most significant contributors ($R_i^{*2} > 4.0$) to the variation in Y_5 and accounted for 49% of the total variation.

A comparison with the category "other accidents ($R^2 = .86$)" in the Los Angeles Study[1] showed that the following present study variables and their coefficient signs were opposite to that of Aldrich's Model: (-)RESTAB(X_{19}); (-)SGL F(X_{16}); (+)ACR PC(X_{32}); (+)PC COM(X_{39}); and (+)PC IND(X_{310}). It appears reasonable that PC COM(X_{39}) would have a positive influence upon other trauma calls since a portion of these calls are violence related and occur primarily in the downtown tracts including the Central Business District which have substantial portions of commercial land. The very low weighting on the effect of PC IND(X_{310}) makes its sign relatively insignificant. The negative sign for RESTAB (X_{19}) for the present study was felt to be intuitive in that violence related injuries would tend to be minimal in more stable, semi-permanent neighborhoods. There is, however, no apparent reason to assume the same relationship for the other types of accidents. Additionally, the author can find no apparent reason to explain the negative effect of SGL F(X_{16}) on other trauma calls. Note that the same, highly important positive influence of ACR PC(X_{32}) has carried through into this category of calls also.

Results of the second-order model which included nine variables are shown in Table 10. R^2 for this model was determined to be .90 indicating an adequate fit for the data. The F statistic was 31.68 ($F_{.01;18,60} = 2.20$) and the t statistics were as shown in the table.

Table 10. Second Order Model, Y_5

Variable Entered	Cumulative R^2	Final Step		
		$\hat{\beta}^k_{ij}$	t Statistic	$R^{*2}_{ij}(\%)$
Constant		36.64		
UNEM M X^2_{110}	.41	0.71	6.59	32.1
PC COM X^2_{39}	.68	0.01	0.77	0.8
INC FA X_{21}	.73	-2.80	-4.42	18.8
UNEM M X_{110}	.79	-5.62	-3.10	10.6
PC SCH X^2_{17}	.82	-0.05	-2.20	5.7
IN POV X^2_{24}	.85	-0.03	-0.90	1.0
RENT X^2_{26}	.87	-0.002	-0.58	0.8
INC FA X^2_{21}	.89	0.01	3.25	11.5
IN POV X_{24}	.89	1.05	0.45	0.3
ACR PC X^2_{32}	.89	-0.01	-0.35	0.2
UNEM F X_{111}	.90	0.44	0.19	0.1
GT 65 X^2_{13}	.90	-0.04	-1.03	1.3
RENT X_{26}	.90	1.11	1.58	3.1
PC SCH X_{17}	.90	1.77	1.25	1.9
PC COM X_{39}	.90	0.41	0.77	0.8
ACR PC X_{32}	.90	0.76	0.78	0.8
GT 65 X_{13}	.90	1.08	0.80	0.8
UNEM F X^2_{111}	.90	0.05	0.35	0.2

Surprisingly, RENT(X_{26}) again appeared with an overall positive effect upon this category. This variable tended to have a moderately significant, positive effect in all first-order models on the various categories and a much more significant effect in some second-order models. Additionally, the same effect resulted with the CBD tracts removed in the analysis of total calls. The author can not reasonably support this result.

Cardio-Vascular and Pulmonary (Y_6)

Table 4 gives the least squares estimates obtained for the 34 parameters plus a constant using the first-order model for cardio-vascular and pulmonary calls. The coefficient of multiple determination was determined to be $R^2 = .88$ indicating an adequate fit to the data. The F statistic was 9.26 ($F_{.01;34,44} = 2.2$) and the t statistics were as shown in the table. The variables ACR PC(X_{32}), ACRES(X_{31}), PC OWN (X_{35}), SGL FM(X_{16}), TR POP(X_{38}), AV AGE(X_{14}), YR SCH(X_{18}), HSE PC(X_{35}), and LT 15(X_{12}) were the most significant contributors ($R_i^{*2} > 4.0$) to the variance in Y_6 and accounted for 62% of the total variance. The results of this model were consistent with expectations except for the positive coefficient for YR SCH(X_{18}) which is unexplainable. A direct comparison with the Los Angeles Study[1] was not possible since the present study included vascular and pulmonary problems which were more general than "cardiac."

Initial runs of the second-order model required 23 first and second-order terms to obtain an R^2 greater than 0.9. The results of the best reduced variable set which included 11 variables are shown in

Table 11. R^2 for this model was .82 indicating an only marginally adequate fit to the data. The F statistic was 11.90 ($F_{.01;22,56} = 2.20$) and the t statistics were as shown in the table.

Table 11. Second-Order Model, Y_6

Variables Entered	Cumulative R^2	Final Step $\hat{\beta}^k_{ij}$	Final Step t Statistic	Final Step R^{*2}_{ij}(%)
Constant		-113.66		
PC COM X^2_{39}	.48	-0.001	-0.06	0.00
FA POV X^2_{23}	.62	-0.001	-0.12	0.03
ACR PC X_{32}	.64	1.19	2.05	7.4
PC SCH X^2_{17}	.67	-0.02	-1.28	3.0
TR POP X^2_{38}	.70	-0.0002	-0.41	0.3
INC FA X_{21}	.72	-0.63	-1.16	2.5
RENT X^2_{26}	.72	0.002	0.60	0.7
HSE PC X^2_{34}	.73	-0.06	-3.91	22.6
HSE PC X_{34}	.77	4.38	3.59	19.7
SGL M X_{15}	.79	0.21	0.41	0.3
MLS LC X^2_{46}	.80	-0.001	-1.29	3.0
TR POP X_{38}	.80	0.23	1.50	4.1
ACR PC X^2_{32}	.80	-0.01	-1.10	2.2
PC SCH X_{17}	.81	0.70	0.88	1.4
SGL M X^2_{15}	.81	0.003	0.47	0.4
PC COM X_{39}	.81	0.17	0.46	0.4
MLS LC X_{46}	.81	0.06	0.59	0.7
INC FA X^2_{21}	.81	0.01	1.35	3.3
FA POV X_{23}	.82	0.33	0.63	0.7
RESTAB X^2_{19}	.82	-0.01	-1.65	4.9
RESTAB X_{19}	.82	0.86	1.61	4.7
RENT X_{26}	.82	-0.10	-0.21	0.1

An unexpected result for this model was the negative weighting on MLS LC(X_{46}) which was expected to be positive. However, this may be due in part to the fact that the relatively more affluent tracts have much more residential, land access route mileage. The other tracts, particularly those tracts surrounding the CBD, have more residential areas lying along traffic movement routes, arterials and collectors. These observations, coupled with the fact that more affluent persons would tend to use family physicians more extensively, particularly for pulmonary problems, tend to support the resultant negative weighting on this variable.

Other Medical (Y_7)

Table 4 gives the least squares estimates obtained for the 34 parameters plus a constant using the first-order model for other medical calls. The coefficient of multiple determination was determined to be $R^2 = .90$ indicating an adequate fit for the data. The F statistic was 11.30 ($F_{.01;34,44} = 2.2$) and the t statistics were as shown in the table. The variables ACR PC(X_{32}), HSES(X_{33}), WRKCOM(X_{41}), ACRES (X_{31}), PC BLK(X_{11}), UNEM M(X_{110}), LT 15(X_{12}), RENT(X_{26}), and TR POP(X_{38}) were the most significant contributors ($R_i^{*2} > 4.0$) to the variance in Y_7 and accounted for 63% of the total variance. The results of this model were consistent with expectations except for the positive coefficient on RENT(X_{26}) which has been previously discussed.

Table 12 gives the results obtained for the best second-order model using a reduced set of 10 variables. R^2 was .90 indicating an adequate fit for the data. The F statistic was 25.93 ($F_{.01;20,58} = 2.20$)

Table 12. Second-Order Model, Y_7

Variables Entered	Cumulative R^2	Final Step $\hat{\beta}^k_{ij}$	$\underline{t}$ Statistic	$R^{*2}_{ij}(\%)$
Constant term		35.33		
PC COM X^2_{39}	.43	0.01	1.18	1.8
FA POV X^2_{23}	.62	-0.01	-1.80	4.1
UNEM M X^2_{110}	.66	0.25	3.79	15.3
PC SCH X^2_{17}	.71	-0.05	-2.68	8.5
VALOW X_{25}	.75	-0.70	-0.58	0.4
PC COM X_{39}	.78	-0.01	-0.03	0.001
ACR PC X^2_{32}	.79	-0.01	-0.84	0.9
PC SCH X_{17}	.80	2.41	2.16	5.8
PC FEM X_{112}	.81	0.15	0.06	0.005
INC FA X_{21}	.82	-2.09	-3.61	14.2
INC FA X^2_{21}	.84	0.01	3.06	10.7
RENT X^2_{26}	.87	0.01	2.47	7.4
ACR PC X_{32}	.88	0.81	1.27	2.1
FA POV X_{23}	.88	0.71	1.26	2.1
UNEM M X_{110}	.89	-0.93	-0.89	1.0
VALOW X^2_{25}	.89	-0.01	-0.16	0.03
RENT X_{26}	.89	-0.70	-1.37	2.4
PC FEM X^2_{112}	.89	-0.01	-0.37	0.2
HSE PC X^2_{34}	.89	-0.04	-2.33	6.6
HSE PC X_{34}	.90	3.02	2.30	6.5

and the $\underline{t}$ statistics were as shown in the table. The only surprising result for this model was the negative weighting on the coefficient for FA POV(X_{23}) which was not consistent with the implications of INC FA(X_{21})'s coefficients. There appears to be no reasonable explanation to support this result.

Dry Runs (Y_8)

Table 4 gives the least squares estimates obtained for the 34 parameters plus a constant using the first-order model for dry runs. The coefficient of multiple determination was determined to be $R^2 = .91$ indicating an adequate fit to the data. The F statistic was 12.72 ($F_{.01;34,44} = 2.2$) and the t statistics were as shown in the table. The variables ACR PC(X_{32}), ACRES(X_{31}), PC BLK(X_{11}), VAL OW(X_{25}), PC COM(X_{39}), UNEM M(X_{110}), GT 65(X_{13}), and PC OWN(X_{35}) were the most significant contributors ($R_i^{*2} > 4.0$) to the variance in Y_8 and accounted for 60% of the total variance.

An unexpected result for this model included the positive coefficient for VAL OW(X_{25}). A possible explanation for this result is that this variable may have operated in the model in a manner similar to RENT(X_{26})'s effect in previous models. Intuitively, both of these variables should have resulted with negative coefficients.

Table 13 gives the results of the best second-order model using a reduced set of seven variables. R^2 for this model was .89 indicating an adequate fit for the data. The F statistic was 38.75 ($F_{.01;14,64} = 2.35$) and the t statistics were as shown in the table.

A Comment on Multicollinearity

A specific problem in multiple regression with which the present research was concerned dealt with multicollinearity and the situation where some or all of the explanatory variables were highly but not perfectly collinear. Appendix D, Table 18, gives the correlation matrix

Table 13. Second-Order Model, Y_8

Variables Entered	Cumulative R^2	Final Step $\hat{\beta}^k_{ij}$	t Statistic	$R^{*2}_{ij}(\%)$
Constant term		42.48		
UNEM M X^2_{110}	.41	0.80	8.63	31.1
PC COM X^2_{39}	.68	0.03	3.84	10.8
UNEM M X_{110}	.75	-8.46	-5.37	18.0
INC FA X_{21}	.81	-1.13	-2.59	5.5
PC SCH X^2_{17}	.84	-0.05	-3.23	8.1
GT 65 X^2_{13}	.85	-0.04	-2.01	3.4
INC FA X^2_{21}	.87	0.004	1.25	1.4
PC SCH X_{17}	.88	2.42	2.38	4.7
ARC PC X_{32}	.89	1.34	1.64	2.3
ACR PC X^2_{32}	.89	-0.02	-1.07	1.0
PC COM X_{39}	.89	-0.51	-1.39	1.7
GT 65 X_{13}	.89	1.05	1.13	1.1
HSE PC X^2_{34}	.89	-0.01	-0.41	0.2
HSE PC X_{34}	.89	0.47	0.27	0.1

that includes correlations among all of the explanatory variables. As indicated by this matrix, some of the explanatory variables were highly collinear. The primary consequence of multicollinearity was the possibility of inefficient predictions, that is, predictions with needlessly large sampling variances. Since the empirical data did not reflect extensive collinearity, however, it was felt that problems associated with multicollinearity would exist but be at minimum levels for the present study. For a discussion of the specific tests which may be conducted for the presence of multicollinearity, the reader is referred to Johnston.[17]

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Table 14 gives a summary of the major results of the present study.

The following conclusions were based upon this research:

1. First-order results show that all categories except OB/GYN and automobile-related trauma were highly predictable using population, economic, geographical and land-use, and transportation variables. ACR PC(X_{32}), ACRES(X_{31}), and UNEM M(X_{110}) tended to be the most consistent, significant variables across all categories. Of lesser significance but still fairly consistent were INC FA(X_{21}), HSES(X_{33}), HSE PC(X_{34}), and WRKCOM(X_{41}). In addition to statistical significance, these variables were consistent with intuition.

2. Second-order results showed vast improvement in the two marginally adequate first-order categories. Additionally, there was a significant reduction in the number of explanatory variables while at the same time maintaining a high R^2 for the remaining categories. The most significant variables for the second-order models were PC COM (X_{39}), UNEM M(X_{110}), INC FA(X_{21}), PC SCH(X_{17}), HSE PC(X_{34}), and ACR PC (X_{32}). These variables were not only much more consistent with intuition but also formed a realistic subset of measurable variables while at the same time being statistically significant.

Table 14. Summary of First and Second-Order Models

	Total Calls	Drug Intox.	OB/GYN	Auto Trauma	Other Trauma	Cardio-vas.	Other Med.	Dry runs
First-order (34 Variables)								
R^2	.93	.95	.74	.78	.90	.88	.90	.91
F	17.98	22.44	3.60	4.72	11.47	9.25	11.30	12.72
Second-order (Reduced set)								
number of original variables	6	7	15	15	9	11	10	7
R^2	.90	.92	.76	.85	.90	.82	.90	.89
F	51.15	52.42	4.97	9.09	31.68	11.90	25.93	38.75

3. The results of a comparison of the present study to the Chicago Study by Gibson, et al.,[14] were extremely poor using a first-order model and only marginally favorable using a second-order model. The single most important result of the comparison was that even though the second-order model was only favorable, the model did show that Chicago's important variables were relevant also to Atlanta but to a lesser degree. This result tends to back the contention that differences between cities will exist by virtue of both measurable and immeasurable factors, but, ultimately, some similar factors in different locales may be used to predict emergency calls.

4. Only a partial comparison with the results of the Los Angeles Study by Aldrich et al.,[1] was possible due to the fact that the Los Angeles study and the presently reported research utilized some different variables in the construction of the regression models. However, some variables for both studies tended in general to show similar significance again backing the contention in 3 above.

5. Removal of the three tracts comprising the Central Business District and a subsequent first-order regression on total calls showed that the significant variables changed. Specifically, AUTOS(X_{42}), SGL F(X_{16}), SGL M(X_{15}), and YR SCH(X_{18}) became significant with the previously important variables becoming of lesser value to the overall model. This result implies that the prediction of emergency calls from exclusively urban areas may possibly be accomplished more effectively with different variables than when considering entire cities.

Recommendations

1. As with all statistical studies, the possibility exists that the base period was too small. Hence, future research should initially concern itself with an expansion of the data base period from one month to a six month and then a 12 month period centered about 1 April, 1970. An analysis of this type would reveal definitive information regarding effects of cyclic variation on the factors in addition to providing results on a yearly per capita basis which would be more favorable for planning purposes. Additionally, a stepwise expansion and analysis procedure may reveal some useful results concerning the emergence of significant factors.

2. Given an expanded data base and still only marginal results for OB/GYN and auto models, second-order models with appropriate interactions should be formulated and tested.

3. Future research should continue to explore the possible use of new variables against Atlanta data. Possible variables are M.D.'s per tract and psychological variables such as specific population's attitudes and perceptions regarding both the emergency medical system in general and ambulance service specifically.

4. Additional research should also conduct a more thorough analysis of the distribution of calls by category through time. If these calls are essentially constant, the possibility should be investigated of predicting only total calls for a given area and then using the distribution against this data (See Appendix D, Time-Series Data).

5. With the formation of the new DeKalb County Ambulance

System and future plans for a centrally controlled regional ambulance system,[4] the resultant models of this research should be tested against current data in a slightly different environment, and, if warranted, new models developed.

6. Finally, serious consideration should be given to an investigation of the clinical records of persons who have called for and used an ambulance in an "emergency" situation. Such an investigation should reveal the distribution of true reasons for calls, as diagnosed by hospital emergency department doctors, against all types of calls received. The distribution of so called "feigned emergencies" would be of particular interest and could have possible significant value in the establishment of central dispatching facilities and the procedures for screening of incoming calls.

A P P E N D I C E S

APPENDIX A

CENSUS TRACTS

The concept of census tracts was originated by Dr. W. Laidow in New York City in 1906 in an effort to produce standardized data for neighborhood studies. At his request in 1910, the U. S. Bureau of the Census tabulated census tract data of New York City and seven other cities with populations over 500,000 persons. By 1970, the Bureau of the Census had expanded its tract statistics to 241 areas (including three in Puerto Rico) now called Standard Metropolitan Statistical Areas (SMSAs) which are a "county or group of contiguous counties which contain at least one city of 50,000 inhabitants or more."[31] (See Figure 1, Atlanta SMSA Map.)

A census tract is a small area into which the SMSAs have been divided by local committees and the Bureau of the Census for statistical reporting purposes. These tracts are designed to be relatively uniform with respect to population characteristics, economic status and living conditions. Additionally, these tracts are designed so that they remain relatively unchanged through time, except for possible sub-division, so that comparability is preserved from census to census.

In the decennial census, the Bureau of the Census tabulates population and housing information for each census tract. Additionally, local agencies such as the Atlanta Regional Commission and the Atlanta City Planning Office collect supplementary data according to census tracts which increases the overall value of tract data in the Atlanta SMSA.

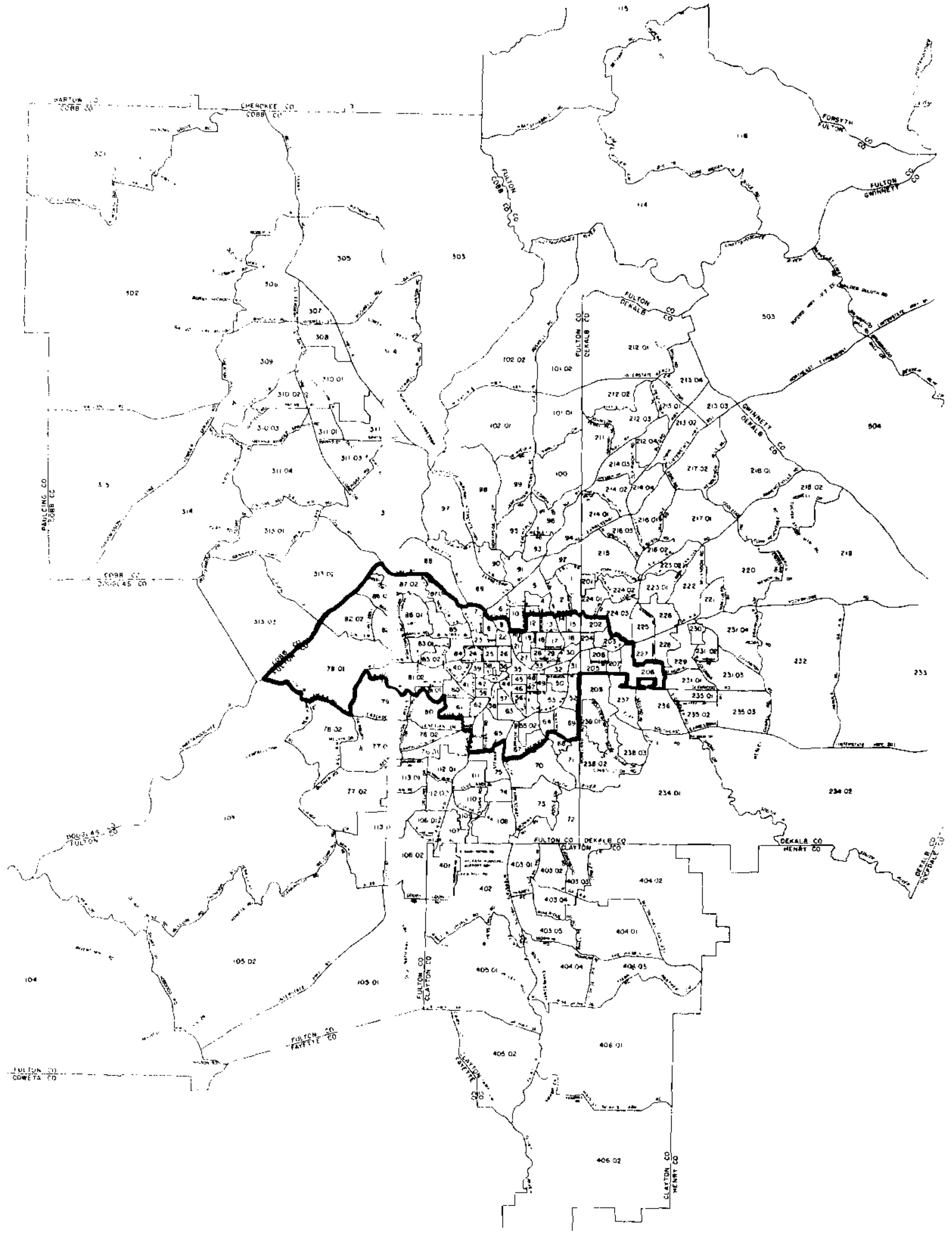

Figure 1. 1970 Census Tracts
(The Boundary of the 79 Tract Area
is indicated by the heavy line.)

APPENDIX B

COMPLETED "REPORT OF OUTSIDE CALL"

No. 19327

Report of Outside Call

GRADY MEMORIAL HOSPITAL

Atlanta, Georgia

Time ______ AM 2:26 PM

Serial

Date 3-6-70 Telephone No. ________ Clinic No. 0075037

Patient Katie [redacted] Sex C/F Age 73

Address and Directions Spring & Marietta St

520 John St N.W.

Reg. Pd.

Description of Case Person down (on street)

Vehicle Involved ☐ Yes ☒ No

Police Signal 62 Street

Referred to Ambulance	Time ____ A.M. 2:26 P.M.	Patton	(Dispatcher)
Arrival of Ambulance at Scene	Time ____ A.M. 2:35 P.M.	Hamilton	(Driver)
Arrival of Ambulance at Hospital	Time ____ A.M. 2:45 P.M.	Brantley	(Attendant)
Referred to Sick Car	Time ____ A.M. ____ P.M.	Date ____	

MEDICAL REPORT

Chief Complaint Pos heart attack

Condition

Treatment

15.0

Disposition of Case MEC

Brantley

Attendant Nurse Doctor

BUSINESS OFFICE

APPENDIX C

ENDOGENOUS AND EXOGENOUS VARIABLES

Endogenous Variables

Calls for each census tract were tabulated as described in Chapter II and then divided by the tract population yielding category calls per capita per tract. These values per tract are listed in Table 17 as indicated in the following table:

Table 15. Endogenous Variables: Computer Output Reference Numbers

Call Category	Table Variable Number
Total calls	35
Drug Intox.	36
OB/GYN	37
Auto trauma	38
Other trauma	39
Cardio-vas.	40
Other medical	41
Dry runs	42

Exogenous Variables

Independent variables as described in Chapter II are for the most part self-explanatory. The following variables, however, require further definition and clarification:

TR POP(X_{38}): As indicated in Chapter II, this variable gives the average transient population residing in a given tract. Since the US Bureau of the Census tabulates data only on the permanent residents of a census tract, TR POP had to be calculated from data derived from other sources. The primary source of data was the Hotel-Motel Association of Georgia which during 1970 maintained statistics on 80 member hotels and motels in the Atlanta SMSA. These member hotels and motels comprised an estimated 90% of the larger establishments (more than 30-40 rooms) in Atlanta and were located primarily in the downtown CBD and along the major expressways.

During 1970, the member firms experienced an average utilization rate of 72.8% occupancy and an average of 1.5 guests per room.

All of the member establishments were plotted by census tract and then the total number of rooms for the census tract was multiplied by the 1970 average utilization rate yielding the average number of persons temporarily residing in the tract.[13] By way of supplementing this data, the author also located all other hotels and motels that were listed in the Nov. 1970 edition of the Atlanta City telephone book. A subsequent survey of 11 of the total of 32 establishments located within the area of operations yielded an average of 42 rooms per motel and 79 rooms per hotel that were normally available as transient lodging. A 100% sample was not possible since some of the non-member establishments were reluctant to discuss any information regarding their businesses. Thus, due to the lack of better information, the average rooms per hotel/motel were then applied against the Hotel/Motel Association's occupancy rate in the same manner as for member firms as previously described. The figures for each tract, mostly insignificant, were added to the number calculated for member establishments yielding the total value of TR POP(X_{38}) per census tract.

MLS XW(X_{43}): This variable indicated the total mileage of freeways and expressways lying within a specific tract's boundary. Freeways and Expressways are defined by the Georgia State Highway Department as streets which are devoted entirely to the task of traffic movement with little or no land as service function. This variable, as with the remaining three route variables, was derived by using a planimeter and the Census maps found in the city block statistics along with 1970 route classification maps published by the State Department of Transportation.[25,26,32]

MLS AR(X_{44}): An arterial is a major street which functions together with the freeway and expressway system for "through" traffic flow, which is traffic passing through an area and not having origin or destination along the particular section of street. Traffic volume is not used as a criterion in itself; however, arterial routes are the most heavily used in an area and daily volumes are usually between 3500 to 5000 vehicles per day.[25,26,32]

MLS CO(X_{45}): A collector is a class of streets that serves the internal movement of traffic within a given urban area and connects this area to the major arterial system. Trip lengths on collectors are normally much smaller than on arterials. Collectors also provide a high degree of land access in addition to serving traffic movement. This classification of routes normally carry from 1000 to 1500 vehicles per day.[25,26,32]

MLS LC(X_{46}): A local is a street which has the sole function of providing access to immediately adjacent land. These routes make up a large percentage of the total street mileage of an urban area but carry a small proportion of the vehicle miles of travel.[25,26,32]

The values of these variables and the other Exogenous variables for each tract are given in Table 17 as indicated in the following table:

Table 16. Exogenous Variables: Computer Output Reference Numbers

Variable	Table Variable Number
PC BLK X_{11}	01
LT 15 X_{12}	02
GT 65 X_{13}	03
AV AGE X_{14}	04
SGL M X_{15}	05
SGL F X_{16}	06
PC SCH X_{17}	07
YR SCH X_{18}	08
RESTAB X_{19}	09
UNEM M X_{110}	10
UNEM F X_{111}	11
PC FEM X_{112}	12
INC FA X_{21}	13
INC UN X_{22}	14
FA POV X_{23}	15
UN POV X_{24}	16
VALOW X_{25}	17
RENT X_{26}	18
ACRES X_{31}	19
ACR PC X_{32}	20
HSES X_{33}	21
HSE PC X_{34}	22

Table 16. (Continued)

Variable	Table Variable Number
PC OWN X_{35}	23
HS AGE X_{36}	24
PC OVC X_{37}	25
TR POP X_{38}	26
PC COM X_{39}	27
PC IND X_{310}	28
WRKCOM X_{41}	29
AUTOS X_{42}	30
MLS XW X_{43}	31
MLS AR X_{44}	32
MLS CO X_{45}	33
MLS LC X_{46}	34

Table 17. Endogenous and Exogenous Variable Values per Census Tract.

Variable Reference Numbers

Census Tract								
		1	2	3	4	5	6	
		7	8	9	10	11	12	13
		14	15	16	17	18	19	20
		21	22	23	24	25	26	27
		28	29	30	31	32	33	34
		35	36	37	38	39	40	41
		42						
202.00000	1	.70000	10.30000	15.57000	38.08560	51.69000	62.97000	
		20.02000	13.00000	24.69000	.00000	6.20000	56.00000	100.79000
		55.19000	2.80000	21.60000	31.10000	105.00000	37.06000	16.82000
		108.70000	49.34000	19.78000	23.74310	2.13400	.00000	.00000
		.00000	99.90000	54.24000	.00000	14.00000	2.00000	49.00000
		22.69000	.00000	.00000	.00000	9.07850	.00000	.00000
		13.61780						

Table 17. (Continued)

203.00000	2	11.50000	22.85000	15.06000	36.02400	32.43000	45.83000	
		17.83000	11.60000	46.09000	.50000	4.60000	55.00000	92.02000
		28.38000	9.80000	31.70000	14.10000	88.00000	48.11000	12.92000
		147.30000	39.55000	50.78000	29.87500	7.03600	.00000	5.00000
		5.00000	133.60000	41.54000	.00000	9.00000	12.00000	63.00000
		40.28000	.00000	.00000	8.05590	8.05590	13.42640	2.68530
		8.05590						
204.00000	3	2.40000	24.55000	10.95000	32.36250	36.56000	45.92000	
		20.65000	10.50000	33.06000	2.90000	5.10000	53.30000	66.87000
		40.57000	16.50000	34.00000	11.10000	93.00000	22.84000	6.79000
		139.90000	41.64000	25.38000	26.10710	7.94400	.00000	5.00000
		5.00000	117.30000	39.19000	.00000	10.00000	14.00000	56.00000
		26.79000	2.97620	.00000	.00000	5.95240	.00000	2.97620
		14.88090						
205.00000	4	97.60000	32.78000	5.95000	27.01470	44.49000	52.57000	
		30.69000	9.30000	55.24000	3.70000	5.80000	53.10000	56.54000
		17.81000	23.40000	51.10000	12.40000	71.00000	40.85000	6.38000
		190.70000	29.78000	37.59000	24.98150	22.01600	.00000	.00000
		10.00000	146.20000	24.11000	.00000	15.00000	10.50000	87.00000
		35.92000	.00000	1.56180	3.12350	9.37060	4.68530	9.37060
		7.80380						
206.00000	5	96.70000	34.77000	7.34000	28.06120	49.71000	61.85000	
		28.43000	8.40000	58.23000	2.60000	4.10000	54.50000	53.76000
		19.25000	34.10000	52.00000	10.80000	55.00000	26.84000	6.41000
		133.00000	31.78000	17.74000	25.44320	25.37400	.00000	14.00000
		14.90000	63.10000	16.97000	.00000	.00000	6.00000	39.00000
		71.68000	.00000	2.38950	2.38950	23.89490	9.55790	11.94740
		21.50540						
207.00000	6	90.20000	35.35000	3.65000	24.81740	43.11000	51.62000	
		29.13000	10.10000	37.46000	2.60000	4.90000	52.80000	75.91000
		34.60000	12.00000	30.40000	12.30000	87.00000	30.74000	6.52000
		125.30000	26.57000	39.19000	21.70930	23.37200	.00000	5.00000
		11.00000	135.70000	25.99000	.00000	4.00000	4.50000	50.00000
		27.57000	4.24090	.00000	2.12040	4.24090	2.12040	6.36130
		8.48180						
208.00000	7	84.80000	36.90000	4.66000	26.02770	42.47000	48.75000	
		34.96000	10.40000	33.21000	3.90000	5.80000	52.20000	82.54000
		33.04000	14.70000	34.50000	14.10000	87.00000	104.11000	9.50000
		265.10000	24.20000	71.52000	23.99460	20.22600	.00000	4.00000
		1.00000	304.00000	27.09000	.00000	26.00000	25.00000	134.00000
		21.91000	.00000	1.82580	54.77450	3.65160	.91290	3.65160
		6.39040						
7.00000	8	45.70000	17.49000	7.05000	31.98330	47.34000	48.43000	
		15.49000	9.50000	30.09000	2.50000	5.20000	33.30000	90.00000
		26.79000	12.20000	32.00000	9.90000	63.00000	43.00000	19.95000
		41.70000	19.35000	43.88000	28.04470	16.20300	.00000	25.00000
		25.00000	36.90000	21.44000	.00000	18.00000	11.00000	35.00000
		23.20000	.00000	.00000	4.64040	13.92110	.00000	4.64040
		13.92110						
8.00000	9	94.90000	32.06000	7.46000	29.37500	50.32000	58.85000	
		24.97000	8.70000	54.79000	4.80000	8.80000	52.80000	51.65000
		16.27000	34.00000	54.50000	10.30000	64.00000	23.70000	6.02000
		128.10000	32.51000	19.98000	20.17550	22.17600	.00000	5.00000
		10.00000	65.00000	16.17000	.00000	13.00000	16.50000	38.50000
		65.99000	7.61420	2.53810	5.07610	17.76650	.00000	17.76650
		15.22840						
9.00000	10	13.10000	9.53000	6.67000	31.26090	84.54000	43.07000	

Table 17. (Continued)

		58.14000	7.20000	25.84000	15.10000	7.30000	29.20000	55.52000
		15.77000	29.80000	55.40000	9.60000	56.00000	19.60000	15.57000
		26.70000	21.21000	22.85000	32.91290	16.81400	.00000	20.00000
		20.00000	17.00000	13.11000	.00000	12.30000	6.00000	33.70000
		111.19000	15.88560	7.94280	.00000	31.77120	.00000	15.88560
		39.71410						
12.00000	11	2.90000	5.30000	16.70000	40.41040	69.05000	68.72000	
		14.61000	12.80000	22.42000	8.80000	2.70000	49.20000	85.73000
		52.71000	6.90000	18.00000	21.00000	104.00000	26.03000	6.13000
		271.00000	63.84000	6.31000	24.16370	4.16200	248.20000	50.00000
		.00000	140.40000	42.07000	.00000	20.50000	20.50000	29.00000
		54.18000	2.35570	.00000	9.42290	9.42290	4.71140	7.06710
		21.20140						
13.00000	12	14.80000	16.49000	10.88000	35.01720	54.17000	56.65000	
		16.70000	11.90000	27.83000	4.30000	6.70000	50.20000	64.88000
		31.54000	13.10000	34.00000	14.90000	89.00000	31.03000	6.38000
		229.80000	47.26000	13.88000	20.14920	8.04800	21.30000	36.00000
		9.00000	158.60000	36.88000	.00000	8.50000	13.00000	40.50000
		78.16000	2.05680	2.05680	10.28380	24.68120	2.05680	20.56770
		16.45410						
14.00000	13	.40000	14.41000	13.77000	37.19240	49.21000	52.93000	
		21.45000	12.20000	38.98000	2.70000	7.20000	52.50000	79.08000
		40.79000	13.20000	26.10000	16.20000	93.00000	18.22000	9.72000
		102.50000	54.69000	24.68000	28.51920	2.82900	.00000	16.00000
		8.00000	77.30000	46.42000	.00000	4.00000	3.50000	27.50000
		53.36000	5.33620	.00000	.00000	16.00850	5.33620	10.67230
		16.00850						
15.00000	14	.50000	11.09000	19.72000	40.33930	49.23000	61.07000	
		16.11000	12.10000	39.05000	7.30000	3.10000	55.70000	82.56000
		39.48000	8.80000	27.90000	16.10000	93.00000	27.07000	5.64000
		258.00000	53.78000	19.88000	27.86640	2.84100	21.80000	16.00000
		.00000	183.20000	43.40000	.00000	7.00000	12.00000	44.00000
		33.35000	2.08460	2.08460	6.25390	6.25390	4.16930	8.33850
		4.16930						
16.00000	15	2.80000	20.01000	12.15000	35.00890	47.31000	52.54000	
		12.63000	11.40000	33.10000	9.40000	1.90000	51.30000	72.39000
		37.86000	10.60000	22.90000	14.70000	84.00000	22.00000	13.58000
		78.70000	46.87000	15.88000	30.34740	8.35700	.00000	11.30000
		16.60000	52.10000	34.72000	.00000	9.00000	6.00000	29.00000
		77.43000	23.82370	.00000	.00000	23.82370	.00000	23.82370
		5.95590						
17.00000	16	92.00000	22.02000	10.34000	33.52440	52.77000	66.74000	
		26.11000	8.80000	52.37000	4.00000	1.80000	56.70000	52.00000
		9.99000	32.60000	47.50000	14.30000	66.00000	29.68000	5.93000
		171.70000	34.28000	18.87000	27.54860	19.25800	.00000	19.40000
		33.00000	94.20000	16.59000	.00000	8.00000	24.00000	33.00000
		61.89000	3.99280	.00000	3.99280	5.98920	13.97480	15.97120
		19.96500						
18.00000	17	90.70000	24.55000	12.80000	35.02020	56.49000	64.41000	
		21.25000	7.50000	52.94000	3.50000	4.00000	53.70000	48.88000
		17.29000	38.80000	55.40000	14.00000	58.00000	22.28000	6.13000
		152.40000	41.95000	9.64000	27.83170	19.70400	8.60000	9.50000
		3.50000	54.70000	12.72000	1.00000	11.00000	22.00000	29.00000
		176.16000	2.75250	5.50510	5.50510	55.05090	27.52550	33.03060
		49.54580						
19.00000	18	6.50000	4.26000	16.13000	41.09800	67.32000	77.24000	
		22.06000	12.40000	25.58000	2.50000	2.90000	58.40000	107.86000

Table 17. (Continued)

		23.77000	4.40000	46.20000	15.80000	163.00000	22.18000	24.84000
		57.30000	64.17000	2.44000	20.05450	4.62600	314.90000	58.80000
		16.60000	16.50000	26.20000	4.00000	20.00000	24.00000	15.00000
		391.93000	44.79280	.00000	44.79280	67.18920	67.18920	89.58570
		89.58570						
20.00000	19	3.10000	9.08000	44.83000	47.88420	78.09000	84.89000	
		29.50000	8.50000	28.29000	.00000	23.10000	57.70000	26.79000
		13.52000	43.30000	77.50000	.00000	36.00000	3.12000	2.60000
		63.70000	53.08000	.31400	20.23260	1.89900	22.50000	8.00000
		2.00000	7.70000	7.50000	.00000	1.00000	6.00000	4.00000
		75.00000	.00000	8.33330	.00000	16.66670	8.33330	33.33330
		8.33330						
21.00000	20	20.50000	31.83000	14.53000	31.95830	53.21000	65.89000	
		33.29000	8.40000	33.60000	6.60000	8.30000	55.10000	32.30000
		13.26000	47.40000	78.30000	12.20000	43.00000	18.53000	8.69000
		78.50000	36.99000	2.03000	20.54440	11.60400	.00000	20.00000
		20.00000	19.60000	14.86000	.00000	16.00000	19.00000	24.00000
		225.04000	14.06470	4.68820	9.37650	60.94700	37.50590	51.57060
		46.88230						
22.00000	21	99.80000	37.96000	7.39000	27.04970	56.28000	70.63000	
		31.46000	8.50000	49.31000	3.80000	6.00000	56.20000	33.07000
		15.70000	52.10000	61.10000	9.70000	54.00000	21.55000	5.84000
		124.40000	33.69000	8.19000	25.12190	23.11500	.00000	15.00000
		40.00000	34.60000	9.18000	.00000	9.00000	8.00000	32.00000
		116.44000	2.70780	16.24690	2.70780	35.20170	13.53910	27.07830
		18.05480						
23.00000	22	90.20000	29.95000	6.83000	29.47700	50.28000	60.26000	
		25.72000	10.20000	52.00000	6.10000	5.60000	53.60000	59.26000
		23.09000	24.80000	43.00000	11.30000	69.00000	26.55000	4.34000
		196.00000	32.18000	23.71000	20.73150	20.83900	.00000	5.00000
		10.00000	139.40000	20.33000	.00000	5.00000	11.00000	40.00000
		34.32000	1.63430	4.90280	1.63430	3.26850	3.26850	11.43980
		8.17130						
24.00000	23	90.80000	23.13000	11.18000	33.71520	46.77000	61.29000	
		22.09000	10.70000	61.02000	2.30000	6.20000	55.90000	65.59000
		28.64000	22.10000	34.70000	14.10000	72.00000	35.80000	6.91000
		173.30000	33.46000	42.29000	22.66370	12.45500	.00000	4.00000
		6.00000	142.80000	23.09000	.00000	11.00000	10.00000	40.00000
		46.34000	3.86180	.00000	5.79260	11.58530	3.86180	5.79260
		15.44700						
25.00000	24	90.90000	27.84000	9.78000	30.65860	58.56000	69.41000	
		28.64000	9.80000	51.72000	5.00000	6.40000	55.80000	46.10000
		14.42000	30.60000	49.80000	12.60000	62.00000	20.83000	3.46000
		200.70000	33.34000	15.79000	25.35540	17.48300	.00000	5.00000
		.00000	98.40000	13.69000	.00000	8.00000	16.00000	32.00000
		49.83000	.00000	3.32230	6.64450	11.62790	3.32230	11.62790
		13.26900						
26.00000	25	90.80000	26.40000	11.32000	33.48350	55.60000	65.68000	
		22.82000	7.80000	58.47000	7.10000	7.50000	54.80000	51.19000
		14.61000	25.30000	61.50000	8.90000	52.00000	22.18000	5.68000
		140.50000	35.97000	13.59000	26.71690	21.76600	4.60000	15.00000
		15.00000	56.00000	9.71000	.00000	8.00000	16.00000	41.00000
		64.02000	2.56080	2.56080	2.56080	5.12160	7.68250	20.48660
		23.04740						
27.00000	26	18.60000	.00000	28.89000	50.95750	86.94000	90.78000	
		3.02000	11.90000	7.82000	3.20000	8.30000	26.90000	.00000
		31.27000	.00000	33.10000	.00000	84.00000	18.74000	24.49000

Table 17. (Continued)

		24.00000	31.37000	.42000	33.93530	8.33300	310.40000	70.00000
		6.00000	6.00000	5.75000	.00000	19.00000	36.00000	13.00000
		836.60000	156.86270	26.14380	39.21570	222.22220	91.50330	143.79080
		169.93460						
28.00000	27	82.70000	25.24000	6.58000	29.65180	56.08000	68.69000	
		31.55000	10.60000	30.07000	2.00000	4.40000	56.70000	58.69000
		16.78000	23.90000	53.60000	10.80000	75.00000	18.12000	6.11000
		99.90000	33.67000	3.50000	13.82830	16.26700	65.70000	29.00000
		5.00000	46.00000	16.89000	4.00000	7.00000	21.00000	12.00000
		131.45000	10.11120	.00000	3.37040	37.04500	26.96330	26.96330
		26.96330						
29.00000	28	99.00000	24.29000	12.48000	35.61800	60.36000	67.32000	
		20.63000	7.60000	63.86000	4.30000	4.60000	53.30000	40.47000
		14.65000	34.60000	60.50000	9.40000	58.00000	17.18000	5.99000
		107.50000	37.47000	12.09000	27.13040	19.32400	.00000	20.00000
		15.00000	28.90000	8.16000	.00000	5.50000	29.00000	5.50000
		104.57000	3.48550	3.48550	6.97100	20.91320	6.97100	27.88430
		34.65540						
30.00000	29	4.50000	29.03000	10.48000	31.48700	42.16000	46.50000	
		19.47000	9.50000	32.68000	7.50000	3.40000	50.50000	70.06000
		17.14000	19.00000	52.80000	11.60000	83.00000	29.88000	9.49000
		127.60000	40.53000	18.10000	25.41660	16.57300	.00000	20.00000
		20.00000	90.40000	28.88000	.00000	12.00000	16.00000	36.00000
		171.54000	9.52990	6.35320	12.70650	66.70900	15.88310	44.47270
		25.41290						
31.00000	30	92.30000	33.67000	6.76000	28.76830	46.79000	56.79000	
		29.61000	8.50000	59.84000	4.70000	4.00000	54.50000	66.52000
		27.50000	21.70000	48.10000	10.90000	69.00000	20.93000	6.41000
		90.70000	27.76000	35.39000	22.85970	23.84300	.00000	5.00000
		15.60000	72.80000	23.23000	.00000	10.00000	.00000	36.00000
		55.09000	.00000	.00000	3.06090	15.30460	.00000	15.30460
		21.42640						
32.00000	31	32.40000	30.97000	10.68000	32.68890	43.77000	50.28000	
		28.37000	7.00000	55.43000	5.10000	2.40000	52.30000	48.87000
		16.09000	37.00000	51.60000	6.20000	57.00000	25.30000	10.76000
		82.30000	35.01000	23.69000	32.15450	24.60300	.00000	10.00000
		28.00000	35.30000	16.46000	.00000	9.00000	.00000	39.00000
		76.50000	.00000	.00000	4.25350	12.76050	17.01400	34.02810
		8.50700						
33.00000	32	98.30000	32.67000	16.11000	32.74080	54.92000	74.07000	
		24.79000	8.20000	52.13000	6.70000	7.10000	58.90000	41.26000
		14.39000	46.30000	68.60000	9.50000	52.00000	17.60000	4.57000
		144.30000	37.44000	4.37000	20.09590	15.87900	.00000	15.00000
		5.00000	33.80000	7.76000	3.00000	8.00000	16.00000	21.00000
		111.57000	2.59470	2.59470	7.78410	25.94710	18.14290	25.94710
		28.54180						
35.00000	33	44.90000	30.09000	22.05000	35.58040	69.23000	78.57000	
		37.35000	8.10000	28.03000	21.10000	10.90000	57.50000	19.51000
		10.61000	70.10000	70.70000	15.80000	42.00000	34.99000	45.38000
		32.60000	42.28000	3.06000	28.51150	9.96900	39.00000	40.00000
		15.00000	3.20000	5.71000	2.00000	36.00000	25.00000	23.00000
		972.76000	103.76140	12.97020	90.79120	298.31390	77.82100	142.67190
		272.37350						
36.00000	34	98.10000	19.53000	6.30000	29.08100	49.55000	74.66000	
		40.05000	11.30000	30.55000	1.90000	4.10000	64.20000	62.73000
		13.60000	10.50000	37.50000	14.20000	80.00000	9.37000	11.58000
		24.70000	30.53000	9.31000	16.41270	9.87100	.00000	35.00000

Table 17. (Continued)

		15.00000	10.90000	17.68000	.00000	4.00000	9.00000	16.00000
		66.53000	.00000	.00000	37.08280	24.72190	.00000	.00000
		24.72190						
37.00000	35	94.60000	27.85000	23.32000	36.95670	57.94000	86.49000	
		25.51000	8.30000	57.85000	6.20000	6.00000	68.10000	26.32000
		11.35000	53.10000	84.60000	.00000	41.00000	2.19000	1.71000
		60.20000	46.96000	.83000	31.51160	11.00000	.00000	.00000
		.00000	6.40000	8.58000	.00000	.00000	1.00000	9.00000
		62.40000	.00000	.00000	7.80030	7.80030	.00000	39.00160
		7.80030						
38.00000	36	98.30000	17.19000	11.29000	31.62640	71.15000	75.10000	
		41.74000	10.90000	43.33000	7.00000	2.40000	53.00000	52.53000
		13.02000	27.60000	52.50000	11.40000	66.00000	19.89000	4.46000
		126.80000	28.42000	22.00000	25.81030	10.31700	.00000	9.00000
		1.00000	72.00000	14.17000	.00000	9.00000	11.00000	32.00000
		40.35000	2.24170	.00000	13.44980	4.48330	2.24170	11.20830
		6.72490						
39.00000	37	94.00000	26.11000	12.02000	33.56050	49.91000	66.03000	
		26.57000	10.50000	56.98000	2.70000	6.20000	56.90000	55.22000
		21.25000	30.50000	48.20000	13.70000	67.00000	19.99000	5.38000
		128.90000	34.66000	36.07000	22.35200	11.55900	.00000	3.00000
		.00000	75.00000	21.16000	.00000	8.00000	9.00000	39.00000
		45.71000	.00000	2.68890	5.37780	8.06670	10.75560	8.06670
		10.75560						
40.00000	38	95.50000	21.07000	11.78000	36.30400	42.83000	54.71000	
		26.91000	12.00000	58.44000	3.40000	6.60000	54.30000	76.25000
		31.25000	16.50000	39.30000	15.60000	78.00000	39.57000	10.09000
		126.70000	32.31000	70.24000	25.17420	7.44100	.00000	2.00000
		2.00000	119.80000	35.04000	6.00000	14.00000	9.00000	50.00000
		45.91000	.00000	5.10070	5.10070	5.10070	5.10070	2.55040
		22.95330						
41.00000	39	52.80000	27.56000	11.67000	31.55280	46.40000	54.23000	
		28.92000	10.00000	32.12000	4.60000	5.20000	52.80000	70.08000
		20.58000	23.90000	49.20000	13.00000	83.00000	28.64000	8.66000
		121.20000	36.66000	32.61000	27.21210	12.44400	.00000	12.00000
		3.00000	90.00000	30.91000	3.50000	7.00000	19.00000	29.50000
		51.42000	6.04960	6.04960	.00000	12.09920	3.02480	12.09920
		12.09920						
42.00000	40	56.40000	38.95000	18.12000	31.08590	50.91000	75.15000	
		31.79000	8.90000	25.94000	3.20000	4.20000	60.90000	39.66000
		14.65000	48.40000	69.60000	12.10000	44.00000	19.16000	8.27000
		89.10000	38.44000	5.05000	14.79520	13.20900	.00000	25.00000
		5.00000	25.70000	11.00000	5.00000	10.00000	9.00000	19.00000
		34.51000	.00000	.00000	4.31400	4.31400	.00000	.00000
		25.68440						
43.00000	41	97.60000	24.02000	12.03000	29.58630	57.36000	86.15000	
		48.28000	8.10000	35.10000	4.30000	16.70000	69.30000	37.41000
		8.05000	45.40000	67.90000	6.70000	46.00000	15.10000	5.71000
		74.50000	28.18000	3.35000	22.81150	17.63900	.00000	25.00000
		8.00000	12.00000	6.05000	.00000	6.00000	7.00000	18.50000
		45.40000	3.78360	.00000	.00000	26.48510	3.78360	3.78360
		7.56720						
44.00000	42	99.60000	40.29000	8.80000	27.14430	56.57000	68.37000	
		31.63000	8.20000	26.19000	7.70000	12.90000	58.10000	36.26000
		13.88000	53.40000	57.80000	7.50000	49.00000	21.97000	6.24000
		124.40000	35.35000	8.68000	13.08800	21.76500	.00000	15.00000
		20.00000	25.90000	8.16000	3.50000	6.00000	16.00000	22.00000

Table 17. (Continued)

		99.46000	.00000	2.84170	5.68340	45.46750	17.05030	17.05030
		11.36690						
45.00000	43	94.50000	33.25000	6.28000	27.47580	55.87000	56.09000	
		24.79000	8.70000	47.40000	3.10000	6.70000	49.70000	43.91000
		46.14000	44.70000	31.50000	12.50000	63.00000	16.35000	19.77000
		29.90000	36.15000	5.68000	15.72630	28.94700	.00000	4.00000
		4.00000	4.50000	4.23000	8.00000	12.00000	7.00000	7.00000
		205.56000	12.09120	12.09120	48.36760	24.18380	36.27570	24.18380
		48.36760						
46.00000	44	99.60000	33.24000	7.58000	30.10080	53.06000	61.22000	
		28.38000	8.20000	58.73000	4.00000	6.70000	53.10000	50.68000
		17.42000	35.00000	57.60000	10.10000	60.00000	13.02000	8.23000
		61.10000	38.62000	9.82000	21.22550	28.86600	.00000	10.00000
		.00000	27.30000	17.69000	3.00000	9.00000	13.00000	10.50000
		132.74000	6.32110	6.32110	6.32110	25.28440	12.64220	44.24780
		37.92670						
47.00000	45	95.60000	29.03000	13.95000	33.66290	58.95000	70.36000	
		17.28000	8.00000	65.78000	5.10000	12.90000	55.90000	34.06000
		11.76000	53.30000	59.70000	8.90000	49.00000	8.85000	5.26000
		77.10000	45.78000	13.75000	29.63150	22.84200	.00000	20.00000
		.00000	22.30000	7.36000	.00000	2.00000	6.00000	23.00000
		160.33000	5.93840	17.81470	.00000	47.50590	11.87650	35.62950
		41.56770						
48.00000	46	72.40000	41.71000	11.19000	28.14060	53.76000	72.32000	
		38.66000	7.10000	26.80000	5.60000	4.50000	57.50000	22.73000
		13.41000	65.80000	77.50000	6.90000	42.00000	9.27000	4.72000
		65.10000	33.11000	1.99000	28.87260	18.86800	.00000	2.00000
		.00000	6.50000	5.69000	3.00000	5.00000	4.00000	18.00000
		91.56000	.00000	5.08650	5.08650	10.17290	15.25940	30.51880
		25.43240						
49.00000	47	10.50000	29.91000	11.14000	32.46120	43.85000	47.96000	
		23.28000	7.90000	41.81000	9.60000	7.70000	50.10000	71.14000
		14.38000	17.70000	60.20000	8.80000	68.00000	15.62000	6.52000
		76.90000	32.08000	22.76000	28.33120	18.66900	.00000	5.00000
		2.00000	50.80000	22.40000	3.00000	2.50000	17.00000	26.50000
		100.13000	8.34370	.00000	12.51560	20.85940	4.17190	25.03130
		29.20320						
50.00000	48	.60000	25.70000	14.79000	35.41720	40.43000	50.53000	
		20.43000	8.40000	34.86000	4.70000	5.10000	53.30000	64.49000
		24.74000	16.00000	42.20000	9.70000	71.00000	32.70000	11.97000
		93.30000	34.16000	30.65000	30.02170	14.10700	.00000	9.00000
		2.00000	71.20000	30.57000	5.00000	10.50000	9.50000	49.00000
		47.60000	.00000	.00000	10.98490	18.30830	10.98490	3.66170
		3.66170						
52.00000	49	2.40000	24.24000	12.59000	35.14340	34.56000	46.13000	
		26.72000	10.30000	46.87000	2.70000	3.70000	53.10000	89.04000
		26.25000	10.80000	42.40000	12.30000	91.00000	55.81000	12.50000
		161.80000	36.25000	53.15000	26.69740	7.05500	5.90000	15.00000
		10.00000	173.50000	44.74000	3.50000	15.00000	10.00000	74.50000
		51.52000	2.24010	2.24010	8.96060	2.24010	11.20070	13.44090
		11.20070						
53.00000	50	53.10000	32.24000	8.98000	29.96900	45.79000	53.38000	
		26.61000	9.00000	34.73000	2.00000	5.90000	52.50000	66.90000
		26.67000	25.70000	35.50000	11.00000	75.00000	49.77000	9.16000
		166.10000	30.57000	34.38000	27.59890	19.19800	.00000	1.00000
		9.00000	115.80000	24.73000	.00000	5.00000	24.00000	76.00000
		40.49000	1.84030	.00000	.00000	11.04160	1.84030	12.88190

Table 17. (Continued)

		12.88190						
55.01000	51	98.80000	33.66000	9.21000	29.68090	52.87000	61.41000	
		28.97000	8.20000	49.52000	5.90000	9.00000	53.50000	38.98000
		11.23000	47.00000	71.20000	9.90000	57.00000	28.95000	5.49000
		163.70000	31.02000	22.72000	26.25340	27.40600	.00000	5.00000
		6.00000	74.50000	12.13000	.00000	8.50000	11.50000	63.00000
		106.12000	.00000	1.89500	3.79000	32.21530	13.26510	24.63500
		32.21530						
55.02000	52	96.30000	40.97000	6.57000	25.14910	56.19000	72.48000	
		39.43000	9.50000	60.15000	4.60000	9.40000	57.30000	37.42000
		13.45000	49.10000	68.90000	9.20000	51.00000	41.23000	7.00000
		161.10000	27.36000	13.90000	20.87290	28.96400	.00000	5.00000
		25.00000	71.80000	10.19000	.00000	11.00000	11.00000	50.00000
		66.23000	3.39620	5.09420	3.39620	11.88865	10.18850	18.67890
		20.37690						
56.00000	53	98.60000	36.57000	5.66000	26.18400	52.41000	56.95000	
		27.15000	8.90000	44.84000	5.20000	6.30000	51.80000	51.93000
		16.53000	32.60000	54.60000	10.60000	65.00000	25.51000	5.14000
		141.90000	28.60000	9.58000	18.02560	32.38900	.00000	9.00000
		14.00000	66.80000	13.14000	5.00000	10.00000	12.00000	30.00000
		118.93000	2.01570	6.04720	10.07860	32.25160	12.09430	28.22010
		28.22010						
57.00000	54	93.30000	26.92000	14.31000	35.17680	52.20000	61.38000	
		27.98000	8.20000	58.67000	3.80000	10.90000	53.60000	51.72000
		20.10000	32.70000	48.70000	9.80000	54.00000	15.52000	6.12000
		87.60000	34.49000	32.80000	27.06200	19.83100	.00000	15.00000
		15.00000	53.90000	17.66000	.00000	6.00000	7.00000	27.00000
		47.29000	.00000	3.94170	3.94170	11.82490	.00000	19.70830
		7.88330						
58.00000	55	5.90000	23.52000	16.41000	36.61020	12.56000	48.72000	
		21.06000	9.20000	38.22000	5.30000	2.80000	54.40000	72.05000
		29.86000	17.00000	34.70000	11.50000	75.00000	30.09000	13.46000
		84.60000	37.84000	39.83000	30.66500	7.88500	.00000	5.00000
		30.00000	65.40000	29.74000	2.00000	22.00000	9.00000	21.00000
		40.25000	.00000	.00000	4.47230	8.94450	.00000	13.41680
		13.41680						
59.00000	56	22.50000	18.83000	20.02000	38.91780	42.63000	60.00000	
		17.77000	9.50000	61.01000	.00000	.00000	56.10000	81.08000
		18.28000	8.90000	53.40000	13.20000	72.00000	13.64000	18.09000
		31.00000	41.11000	31.94000	20.29210	8.60900	.00000	20.00000
		5.00000	22.30000	34.75000	.00000	10.00000	9.00000	13.00000
		106.11000	.00000	.00000	13.26260	.00000	13.26260	13.26260
		66.31290						
60.00000	57	74.20000	28.05000	9.10000	30.28280	42.21000	52.74000	
		24.55000	10.80000	23.28000	1.40000	7.60000	54.90000	82.48000
		24.67000	13.00000	42.80000	16.20000	106.00000	37.69000	6.83000
		179.00000	32.45000	57.04000	22.71680	10.69100	.00000	8.00000
		.00000	167.00000	32.29000	.00000	7.00000	13.00000	61.00000
		25.38000	3.62580	.00000	3.62580	5.43870	.00000	7.25160
		5.43870						
61.00000	58	66.40000	33.39000	7.53000	28.66250	37.28000	48.76000	
		29.46000	11.50000	27.06000	3.00000	9.30000	53.80000	87.84000
		21.02000	11.30000	45.10000	16.00000	80.00000	54.98000	9.48000
		172.10000	29.67000	74.72000	22.59460	13.11900	.00000	3.00000
		.00000	176.30000	33.94000	.00000	7.00000	24.00000	100.00000
		13.79000	.00000	3.44770	1.72380	1.72380	.00000	5.17150
		1.72380						

Table 17. (Continued)

62.00000	59	37.80000	31.36000	11.17000	31.58030	38.62000	51.54000	
		22.55000	9.00000	45.00000	.80000	5.50000	53.40000	75.85000
		32.27000	11.40000	41.40000	13.00000	71.00000	25.20000	10.09000
		83.40000	33.40000	41.01000	26.21800	16.83900	.00000	20.00000
		5.00000	66.50000	30.16000	.00000	9.00000	18.00000	38.00000
		40.05000	.00000	12.01440	8.00960	.00000	.00000	8.00960
		12.01440						
63.00000	60	96.50000	28.84000	11.20000	32.46330	51.12000	59.95000	
		29.67000	8.40000	65.37000	1.90000	4.50000	54.10000	56.32000
		16.60000	24.10000	56.40000	0.80000	55.00000	35.92000	7.58000
		150.50000	31.75000	32.82000	25.99310	22.03500	.00000	10.00000
		20.00000	86.40000	17.94000	4.50000	5.00000	14.00000	62.50000
		67.52000	.00000	2.11020	6.33040	16.88120	8.44060	21.10150
		12.66090						
64.00000	61	7.70000	24.36000	10.40000	32.51570	33.33000	41.94000	
		23.83000	9.60000	31.75000	4.00000	11.30000	53.30000	78.28000
		30.42000	10.70000	23.90000	10.20000	75.00000	29.05000	17.18000
		62.40000	36.90000	29.49000	24.83790	7.05900	.00000	22.50000
		22.50000	60.90000	39.74000	.00000	11.50000	3.00000	20.50000
		47.31000	11.82730	.00000	5.91370	.00000	.00000	17.74090
		11.82730						
65.00000	62	.20000	17.24000	17.31000	40.89380	31.08000	45.87000	
		20.29000	11.00000	61.21000	2.50000	4.00000	55.30000	102.27000
		28.50000	4.70000	28.70000	14.40000	93.00000	78.13000	16.21000
		190.10000	39.45000	71.17000	26.52640	2.88800	4.60000	5.00000
		10.00000	185.60000	50.51000	8.50000	8.00000	15.00000	94.50000
		16.60000	.00000	.00000	4.15020	2.07510	.00000	4.15020
		6.22540						
66.01000	63	7.40000	19.41000	17.25000	39.16230	31.94000	48.52000	
		19.01000	11.30000	65.88000	1.50000	1.60000	56.10000	93.41000
		23.75000	11.00000	41.10000	13.90000	75.00000	42.19000	15.45000
		103.60000	38.00000	62.66000	29.05940	5.04500	.00000	42.50000
		7.50000	93.90000	45.53000	.00000	7.50000	21.50000	56.00000
		29.30000	3.66300	.00000	3.66300	.00000	3.66300	7.32600
		10.98900						
66.02000	64	7.20000	25.90000	9.39000	31.35120	28.74000	39.31000	
		18.83000	10.50000	41.25000	2.20000	10.90000	53.60000	78.33000
		47.80000	14.10000	20.00000	13.60000	84.00000	17.79000	10.06000
		69.80000	39.48000	33.24000	22.54240	6.33700	.00000	8.00000
		.50000	56.50000	43.83000	.00000	9.00000	4.00000	24.00000
		50.90000	.00000	.00000	5.65610	16.96830	5.65610	5.65610
		16.96830						
67.00000	65	75.00000	35.00000	7.03000	27.51320	40.50000	56.46000	
		25.02000	9.40000	43.15000	4.00000	8.90000	55.70000	50.88000
		16.95000	29.00000	53.10000	11.00000	63.00000	85.38000	10.91000
		257.70000	32.94000	29.22000	20.60090	16.04400	.00000	6.00000
		6.00000	161.40000	22.47000	12.00000	15.00000	17.00000	98.00000
		48.57000	.00000	6.39140	5.11310	8.94790	1.27830	11.50450
		15.33940						
69.00000	66	.70000	24.64000	8.08000	31.98520	25.29000	33.93000	
		30.45000	10.20000	40.47000	2.50000	6.40000	51.40000	83.74000
		19.95000	8.90000	43.60000	12.70000	77.00000	76.53000	18.67000
		146.80000	35.81000	47.62000	20.85400	5.39600	.00000	8.00000
		2.00000	231.20000	43.82000	.00000	19.00000	17.00000	73.00000
		29.28000	.00000	.00000	2.43960	12.19810	4.87920	2.43960
		7.31390						
78.01000	67	93.20000	34.97000	2.60000	23.80360	33.46000	45.08000	

Table 17. (Continued)

		30.68000	12.30000	39.90000	2.40000	3.40000	53.80000	87.53000
		53.64000	10.80000	28.50000	17.50000	89.00000	615.97000	38.63000
		450.90000	28.28000	42.12000	8.85510	11.34100	35.50000	22.40000
		20.60000	560.60000	33.58000	34.00000	39.00000	70.00000	195.00000
		13.17000	.62710	.62710	2.50850	1.88140	.00000	1.88140
		5.64400						
81.01000	68	87.30000	36.32000	2.70000	24.61690	29.99000	36.07000	
		37.02000	12.30000	5.20000	1.40000	3.60000	50.50000	109.00000
		35.63000	2.40000	25.50000	19.00000	113.00000	21.80000	14.04000
		40.50000	26.08000	92.59000	16.19660	9.47600	.00000	.00000
		.00000	55.30000	42.05000	.00000	.00000	3.00000	26.00000
		6.44000	.00000	.00000	.00000	.00000	.00000	6.43920
		.00000						
81.02000	69	99.10000	29.24000	3.99000	27.14540	37.21000	48.94000	
		28.14000	12.50000	42.98000	3.70000	2.60000	53.70000	91.32000
		52.96000	8.00000	23.10000	20.10000	101.00000	170.31000	25.92000
		211.00000	32.12000	45.64000	10.03890	8.57400	.00000	4.00000
		1.00000	256.30000	35.91000	10.50000	25.00000	7.00000	82.50000
		15.22000	.00000	1.52200	7.61040	1.52200	.00000	1.52200
		3.64410						
82.01000	70	97.20000	25.65000	5.75000	31.75960	37.12000	46.66000	
		31.69000	12.60000	71.14000	2.40000	3.70000	53.30000	116.64000
		32.00000	4.90000	36.70000	21.50000	82.00000	122.41000	17.01000
		201.20000	27.96000	89.36000	11.53950	6.18100	.00000	.50000
		3.00000	306.00000	43.05000	16.00000	19.50000	13.00000	161.50000
		6.05000	.00000	.00000	.00000	1.38950	1.38950	2.77890
		1.38950						
82.02000	71	94.20000	34.94000	2.90000	25.03650	37.92000	45.68000	
		29.51000	11.20000	56.85000	2.00000	5.90000	52.60000	82.57000
		38.55000	13.60000	26.80000	14.20000	99.00000	174.77000	40.23000
		114.60000	26.43000	63.59000	10.60350	20.91900	4.60000	4.00000
		32.00000	126.40000	29.12000	10.00000	30.00000	19.00000	60.00000
		57.55000	.00000	16.11420	4.60400	20.71820	2.30200	6.90610
		9.20810						
83.01000	72	99.60000	28.88000	5.51000	28.85720	39.76000	50.29000	
		26.62000	10.90000	54.85000	4.20000	5.50000	54.10000	73.71000
		36.56000	16.90000	25.50000	14.50000	80.00000	64.36000	11.94000
		164.40000	30.49000	49.94000	15.87070	13.40000	.00000	2.50000
		2.50000	142.10000	27.56000	2.00000	7.00000	28.00000	46.00000
		27.82000	.00000	.00000	1.85490	1.85490	3.70990	7.41980
		12.68460						
83.02000	73	94.90000	28.48000	7.33000	29.86780	46.71000	56.65000	
		25.62000	10.80000	53.61000	2.90000	8.40000	53.70000	71.26000
		29.68000	17.30000	37.20000	14.80000	75.00000	43.41000	7.19000
		180.40000	29.91000	37.08000	16.76800	16.04600	.00000	5.00000
		.00000	160.10000	26.16000	.00000	.00000	9.00000	62.00000
		18.24000	1.65780	.00000	3.31570	6.63130	.00000	1.65780
		4.97350						
84.00000	74	99.20000	27.81000	4.93000	27.89090	41.44000	54.38000	
		24.69000	11.70000	50.25000	6.10000	3.80000	55.20000	75.66000
		31.70000	11.40000	36.20000	14.70000	80.00000	42.48000	5.83000
		229.60000	31.49000	28.70000	14.56420	14.28600	.00000	7.00000
		3.60000	198.50000	24.64000	.00000	.00000	19.00000	58.00000
		23.32000	1.37190	1.37190	1.37190	4.11580	.00000	2.74390
		12.34740						
85.00000	75	97.40000	33.43000	3.85000	26.14360	45.26000	52.21000	
		31.44000	11.00000	53.39000	4.70000	4.80000	52.50000	82.33000

Table 17. (Continued)

		36.48000	15.30000	32.40000	13.60000	84.00000	89.86000	10.36000
		236.50000	27.26000	46.30000	17.62930	19.84200	4.60000	8.00000
		7.00000	237.70000	26.20000	.00000	12.00000	14.00000	107.00000
		40.35000	1.15270	1.15270	2.30540	4.61090	5.76370	3.45820
		21.90200						
86.01000	76	93.20000	33.61000	5.97000	27.22670	45.34000	51.73000	
		31.62000	9.90000	38.84000	5.20000	6.60000	52.10000	74.33000
		30.54000	12.50000	38.80000	12.60000	83.00000	111.41000	15.19000
		196.40000	26.84000	54.75000	16.07070	19.30200	.00000	9.00000
		1.60000	198.60000	25.84000	.00000	34.00000	8.00000	111.00000
		28.63000	.00000	2.72670	2.72670	5.45330	1.36330	9.54330
		6.61660						
86.02000	77	93.80000	54.69000	2.87000	19.20080	50.14000	70.26000	
		47.49000	9.90000	36.97000	8.10000	7.80000	56.20000	36.34000
		14.47000	51.70000	59.10000	12.60000	52.00000	107.99000	18.32000
		136.50000	23.16000	17.22000	8.79030	38.15800	.00000	4.00000
		11.60000	51.50000	10.42000	7.00000	30.50000	2.00000	47.50000
		37.32000	1.69640	1.69640	3.39270	13.57080	.00000	13.57080
		3.39270						
87.01000	78	94.80000	50.05000	2.21000	19.52630	56.84000	71.94000	
		46.62000	10.10000	42.26000	12.50000	10.90000	55.50000	35.66000
		17.35000	53.70000	57.20000	13.20000	56.00000	87.68000	13.15000
		153.10000	22.97000	2.87000	14.57920	35.49000	.00000	2.00000
		23.00000	54.30000	7.25000	.00000	.00000	24.00000	33.00000
		66.00000	.00000	13.50140	6.00060	21.00210	9.00090	3.00030
		13.50140						
87.02000	79	93.10000	39.12000	3.13000	24.88630	44.67000	55.15000	
		34.39000	9.80000	55.63000	4.10000	5.50000	54.10000	65.05000
		18.53000	29.40000	50.60000	12.30000	64.00000	104.44000	21.81000
		122.60000	25.61000	56.44000	12.28470	24.42400	.00000	.00000
		.00000	96.30000	21.19000	.00000	6.00000	12.00000	34.00000
		48.04000	.00000	6.26570	2.08860	2.08860	4.17710	18.79690
		14.61990						

APPENDIX D

CORRELATION MATRIX

The correlation matrix for correlations among exogenous and endogenous variables is given in Table 18. The same numbering system as described in Tables 15 and 16 apply to this matrix.

Table 18. Matrix of Correlation among Endogenous and Exogenous Variables.

Variable Number	Correlation Matrix																			
1	1.00000																			
2	.58030	1.00000																		
3	-.51019	-.58799	1.00000																	
4	-.61485	-.84964	.86970	1.00000																
5	.12531	-.28738	.37452	.27308	1.00000															
6	.26006	-.09182	.47574	.25009	.75353	1.00000														
7	.41834	.48236	-.37602	-.60822	.18431	.13906	1.00000													
8	-.19748	-.35691	-.10062	.11658	-.25886	-.24917	-.26596	1.00000												
9	.41985	.21341	-.15708	-.09241	-.19021	-.06074	-.05332	-.23203	1.00000											
10	-.00963	.13600	-.01752	-.12415	.39656	.20512	.34430	-.30285	-.14414	1.00000										
11	.06446	.08778	.29924	.02937	.33123	.33227	.23229	-.30288	-.14634	.12925	1.00000									
12	.26837	.31437	.06573	-.15923	-.20420	.32258	.20650	-.08026	.27577	-.12731	.11648	1.00000								
13	-.20506	-.24936	-.27891	.00681	-.62464	-.71430	-.23449	.66200	-.00807	-.39220	-.45932	-.07497	1.00000							
14	-.26553	-.25682	-.15222	.05645	-.35544	-.47843	-.38983	.69429	-.18558	-.27445	-.27541	-.24558	.61397	1.00000						
15	.39048	.50712	.09422	-.25701	.44097	.57773	.46238	-.72077	.14532	.45606	.43349	.33835	-.81883	-.64854	1.00000					
16	.26450	.32873	.26660	-.05623	.44924	.59827	.42106	-.72844	.15615	.31713	.36546	.33447	-.72090	-.85982	.80997	1.00000				
17	-.08212	-.09716	-.34360	-.13597	-.35344	-.39792	-.06674	.66435	-.07145	-.10589	-.40247	.05829	.69724	.60132	-.47635	-.59510	1.00000			
18	-.33291	-.40251	-.15665	.14864	-.31460	-.41840	-.34567	.78064	-.29426	-.32666	-.42901	-.15992	.77869	.65900	-.80257	-.73742	.60295	1.00000		
19	.16883	.22002	-.32862	-.32847	-.29015	-.28630	.12507	.32512	.04450	-.08614	-.14400	-.02846	.28127	.39842	-.20259	-.26531	.28358	.21027	1.00000	
20	-.16146	-.04053	-.07866	-.02362	-.12521	-.20617	.03559	.29977	-.17109	.14414	-.12293	-.23814	.24179	.34753	-.20492	-.30679	.30297	.30707	.56601	1.00000

Table 18. (Continued)

21	.21854	.15619	-.32269	-.26245	-.25036	-.23255	-.04412	.38677	.16584	-.07061
	-.19099	.09447	.29625	.33860	-.23241	-.28162	.37120	.24061	.63846	-.01784
	1.00000									
22	-.55038	-.57468	.63360	.68195	.18440	.24424	-.52730	.19002	-.13958	-.02414
	-.00446	.23427	.07611	.18589	-.08248	-.05721	.13490	.27986	-.25600	-.08730
	-.07254	1.00000								
23	.02668	.08350	-.34767	-.16929	-.67050	-.72418	-.02460	.44146	.16948	-.36932
	-.26535	-.13995	.72724	.37696	-.58608	-.51867	.42463	.42902	.31886	.23799
	.28561	-.37577	1.00000							
24	-.49910	-.46383	.49284	.60006	.17333	.06425	-.37256	-.31784	-.02429	.13911
	-.07237	-.24710	-.13648	-.21934	.01687	.14202	-.30202	-.14792	-.47993	-.26464
	-.33350	.32270	-.19276	1.00000						
25	.63712	.73482	-.51952	-.67363	.17141	.14719	.41137	-.55920	.30089	.22827
	.12789	.00189	-.47500	-.41188	.55816	.40396	-.32148	-.48742	-.00652	-.16864
	-.01037	-.55323	-.23026	-.24759	1.00000					
26	-.27210	-.51948	.33390	.47862	.44582	.36264	-.30881	.32848	-.38593	.02869
	-.07039	-.29444	-.01239	.17743	-.24424	-.14738	-.02592	.44465	-.01506	.24183
	-.04167	.42633	-.26583	.07308	-.26171	1.00000				
27	-.34954	-.53669	.38005	.49480	.43636	.37277	-.26126	.13690	-.36541	.12582
	-.04594	-.23877	-.11779	-.02909	-.12704	-.02230	-.09717	.18989	-.06564	.26461
	-.19297	.36630	-.32175	.23182	-.29755	.74114	1.00000			
28	.00783	.13311	-.15405	-.15477	.01320	.00375	.14342	-.26394	.07343	.18585
	-.06276	-.10135	-.15886	-.19385	.18864	.09448	-.17054	-.14679	.12396	.22159
	-.10298	-.10968	-.18144	.07792	.28199	-.02662	.17415	1.00000		
29	.09620	.07810	-.36245	-.23788	-.46296	-.49731	-.04345	.53377	.11066	-.20824
	-.26094	-.03266	.55427	.52378	-.48515	-.48022	.47220	.41550	.77972	.25824
	.86240	-.18370	.57599	-.37739	-.20026	-.08150	-.21366	-.14780	1.00000	
30	-.54031	-.34712	-.06532	.20275	-.64070	-.69191	-.39138	.69526	-.08176	-.37184
	-.37775	-.07635	.87048	.67386	-.80353	-.73998	.65236	.71759	.20491	.19455
	.28543	.26296	.63202	.02334	-.64744	-.01435	-.07665	-.22683	.51209	1.00000
31	.15577	.17710	-.20813	-.20976	-.22334	-.18035	.09009	.22235	.08153	-.09583
	-.13998	.04139	.20550	.29979	-.09296	-.13839	.22238	.13701	.82357	.50815
	.45697	-.13628	.20128	-.47843	-.03512	.02529	-.04204	.07923	.58088	.12072
	1.00000									
32	-.07569	.02129	-.11160	-.07287	-.09357	-.14415	.06336	.21872	-.15568	.17930
	-.13761	-.20499	.15562	.30732	-.13604	-.20452	.28104	.22896	.57564	.71337
	.27451	-.08144	.17543	-.23363	-.07931	.24940	.20702	.18133	.41821	.13168
	.50421	1.00000								

Table 18. (Continued)

33	.06306	-.03703	-.05033	.01202	.03979	.01178	-.10950	.19562	-.07767	.04989
	-.11391	-.14786	.03282	.11535	-.13403	-.08419	.09499	.16576	.62709	.37557
	.48762	-.05480	.02663	-.16015	-.05905	.33921	.34397	.10439	.47819	-.02096
	.49812	.36392	1.00000							
34	.13781	.19639	-.38998	-.30072	-.43548	-.48141	.08467	.38019	.15953	-.17490
	-.19006	-.05568	.48287	.36104	-.37180	-.33458	.38680	.28840	.72184	.27830
	.75463	-.33345	.63055	-.32055	-.06544	-.14718	-.27380	-.07538	.90314	.41015
	.57171	.45865	.39886	1.00000						
35	-.14499	-.22333	.38828	.36367	.51103	.44081	-.11079	-.11570	-.27926	.43535
	.15647	-.24603	-.43998	-.17625	.23218	.21447	-.20402	-.07128	-.14029	.44367
	-.36039	.19157	-.30803	.24062	-.05164	.54930	.60105	.10351	-.34115	-.35891
	-.05764	.29605	.26727	-.29448	1.00000					
36	-.21342	-.33604	.37877	.42241	.46805	.36505	-.20231	.06677	-.36473	.32409
	.11254	-.41184	-.34118	-.02733	.00681	.02197	-.20422	.06645	-.08836	.43896
	-.30509	.12288	-.27973	.24826	-.15251	.64320	.62976	.05590	-.23357	-.22680
	-.05350	.28703	.29617	-.20607	.92615	1.00000				
37	.11473	.06988	.15678	.06665	.43991	.32017	-.00612	-.19005	-.04654	.22275
	.33268	-.32449	-.51322	-.13866	.32097	.20721	-.30881	-.24586	-.03392	.25820
	-.23153	-.07748	-.25038	.06119	.27850	.24323	.24045	.17344	-.26650	-.44163
	.00130	.11364	.17362	-.20654	.56570	.53681	1.00000			
38	-.07202	-.12134	.19383	.16884	.29393	.27225	.00905	-.00184	-.24735	.34733
	.01210	-.04965	-.17878	-.03407	.11566	.04595	.00883	.07900	-.05934	.45465
	-.21823	.13532	-.21316	.08192	-.05915	.38168	.44201	.01322	-.14502	-.22073
	.00920	.38218	.22318	-.11652	.74924	.62534	.29871	1.00000		
39	-.12769	-.17076	.34829	.30311	.48162	.41015	-.06488	-.13084	-.30250	.49680
	.21733	-.25629	-.45457	-.19284	.26723	.21818	-.18219	-.12791	-.11980	.43276
	-.32067	.13782	-.37961	.22443	-.03400	.45245	.55222	.13008	-.31095	-.35116
	-.06521	.30605	.25542	-.25532	.97396	.89029	.55313	.70273	1.00000	
40	-.14239	-.23384	.37205	.37792	.49011	.45327	-.15365	-.08974	-.24928	.25153
	.08537	-.20241	-.39179	-.16698	.20824	.21820	-.21104	.01316	-.15487	.35793
	-.33571	.24828	-.41885	.19418	-.03339	.64369	.59940	.10417	-.34514	-.35464
	-.03408	.23673	.25313	-.30219	.91872	.84112	.50280	.68123	.85010	1.00000
41	-.15273	-.21878	.44913	.40923	.54434	.48462	-.14859	-.20776	-.23534	.39142
	.16752	-.21936	-.48769	-.27314	.27919	.33149	-.34553	-.10231	-.18800	.32118
	-.39063	.26510	-.45625	.30386	-.00954	.57572	.57570	.13382	-.40271	-.41308
	-.09415	.21733	.22002	-.35440	.94650	.87642	.53814	.64062	.89969	.90172
	1.00000									
42	-.12834	-.20485	.36004	.33356	.46556	.39756	-.07523	-.13925	-.21231	.46236
	.10832	-.20217	-.33438	-.17216	.24348	.22015	-.11393	-.09362	-.13563	.46893
	-.35143	.16608	-.35908	.23884	-.06319	.46476	.56179	.07001	-.32399	-.32281
	-.05895	.31127	.25348	-.27959	.96624	.85288	.48572	.76125	.93748	.85312
	.87829	1.00000								

APPENDIX E

TIME-SERIES DATA, GRADY MEMORIAL HOSPITAL

An initial planning objective for this research included a time-series analysis of calls received exclusively by Grady Memorial Hospital. Real time considerations, however, forced a re-evaluation of this objective after the data had been collected and prior to an extensive analysis. Since the data were collected, it will be presented here so that future research into this specific subject will be assisted.

Table 19 gives the monthly values of both emergency (including private ambulance back-up calls) and non-emergency ambulance calls serviced by Grady Hospital from Jan. 1966 to March, 1973. Code 82's, transportation, were calls received by the ambulance department for convalescent transportation plus miscellaneous runs for blood, laundry, and also the transportation of patients from one hospital to another or former patients to the county morgue. Social service stretcher calls are non-emergency ambulance requiring calls which are scheduled on a daily basis, approximately constant by policy, by the Social Service Department of the Hospital. Elective runs are transportation runs conducted by two step-vans which have the capability of carrying four sit-down and six wheel-chair patients. The data in the table were obtained from official records maintained by the hospital plus the dispatcher's log books.[11,28]

Table 20 gives the distribution of call codes using the base month plus four seven-day samples and a two-week sample of "Reports of Outside Calls." The seven day samples each consisted of one day of each day of the week randomly selected from the available calendar days for a preselected month. The large interval from the base month to sample one was due to the relative inaccessibility of the filed "Reports of Outside Calls" for that period.

Table 21 gives the distribution of the call categories as developed by the present research across each of the sample points.

Figure 19. Ambulance Calls Received by Grady Memorial Hospital

Legend:

Emer. = total emergency calls answered by Grady Hospital
Pvt. = total private ambulance, back-up runs as requested by Grady Hospital
Code 82 = transportation or convalescent calls run by Grady Hospital
Stretcher = social service transportation calls
Van = Step-van runs for wheelchair and sit-down out-patients
Total Grady = Emer. + Code 82 + Stretcher + Van

1966

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Emer.								954	859	890	832	850
Pvt.								206	146	144	133	116
Total Emer								1160	1005	1034	965	966
Code 82			***Missing Log Books***									
Stretcher												
Van												
Total Amb.								428	428	512	533	591
Total Grady	1056*	1002	1217	1156	1295	1231	1342	1382	1287	1402	1365	1441

1967

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Emer.	735	790	1068	939	837	989	1166	1201	1212	Missing Log Book	1163	1301
Pvt.	136	75	104	151	110	53	63	79	83		59	41
Total Emer.	871	865	1172	1090	947	1042	1229	1280	1295		1222	1342
Code 82												
Stretcher												
Van												
Total Amb.	567	481	372	529	645	412	475	560	485		589	521
Total Grady	1302	1271	1440	1468	1482	1401	1641	1761	1697	1772	1752	1822

*"Total Grady" Data for 1966 and 1967 obtained from Wilmont.[36]

Table 19. (Continued)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
						1968						
Emer.	1174	1030	1113	1189	1428	1314	1298	1427	1311	1457	1405	1484
Private	178	130	104	101	166	102	83	117	93	158	118	119
Total Emer.	1352	1160	1217	1290	1594	1416	1381	1544	1404	1615	1523	1603
Code 82										366	379	310
Stretcher										87*	117	100
Van										243*	253	170
Total Amb.	611	552	572	517	520	471	541	549	579	696	749	580
Total Grady	1785	1582	1685	1706	1948	1785	1839	1976	1890	2153	2154	2064
						1969						
Emer.	1418	1383	1346	1530	1725	1853	2060	2237	**Missing Log Books**			
Private	80	47	123	109	132	177	232	162	47	91	80	70
Total Emer.	1498	1430	1469	1639	1857	2030	2292	2399	**Missing Log Books**			
Code 82	274	228	324	326	222	303	329	310	**Missing Log Books**			
Stretcher	119	118	129	109	142	174	124	117	149	156	148	182
Van	314	377	388	421	412	319	302	292	320	373	308	315
Total Amb.	707	723	841	856	776	796	755	719	**Missing Log Books**			
Total Grady	2125	2106	2187	2386	2501	2649	2815	2956	2807	3139	3076	3084
						1970						
Emer.	2116	1998	2357	2532	2546	2396	2689	2677	2481	2653	2312	2510
Private	92	114	91	71	64	53	34	29	40	39	34	67
Total Emer.	2208	2112	2448	2603	2610	2449	2723	2706	2521	2692	2346	2577
Code 82	424	365	378	329	272	305	266	327	262	252	294	303
Stretcher	129	107	203	151	184	183	134	118	116	130	114	119
Van	304	281	299	319	328	351	310	270	269	310	265	270
Total Amb.	857	753	880	799	784	839	710	715	647	692	673	692
Total Grady	2973	2751	3237	3331	3330	3235	3399	3392	3128	3345	2985	3202

*New bookkeeping procedure plus addition of elective van.

Table 19. (Continued)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
						1971						
Emer.	2251	2034	2318	2394	2472	2477	2663	2817	2677	2715	2520	2666
Private	75	156	68	59	59	33	71	61	51	81	60	68
Total Emer.	2326	2190	2386	2453	2531	2510	2734	2878	2728	2796	2580	2734
Code 82	328	370	416	325	329	261	346	324	366	364	315	351
Stretcher	142	138	148	130	117	155	140	125	132	130	160	142
Van	333	299	344	326	255	285	307	319	289	254	252	223
Total Amb.	803	807	908	781	701	701	793	768	787	748	727	716
Total Grady	3054	2841	3226	3175	3173	3178	3456	3585	3464	3463	3247	3382
						1972						
Emer.	2784	2452	2715	2835	3037	2886	3140	3046	3142	3026	2996	3175
Private	55	74	81	38	81	102	78	94	90	61	51	82
Total Emer.	2839	2526	2796	2873	3118	2988	3218	3140	3232	3087	3047	3257
Code 82	338	399	413	327	409	364	398	433	421	408	447	459
Stretcher	119	111	134	120	145	113	139	197	147	148	141	129
Van	261	307	309	275	396	396	407	537	462	380	446	354
Total Amb.	718	817	856	722	950	873	944	1167	1030	936	1034	942
Total Grady	3502	3269	3571	3557	3987	3759	4084	4213	4172	3962	4030	4117
						1973						
Emer.	3191	2732	3137									
Private	65	91	99									
Total Emer.	3256	2823	3236									
Code 82	472	372	371									
Stretcher	97	132	116									
Van	509	534	587									
Total Amb.	1078	1038	1074									
Total Grady	4269	3770	4211									

Table 20. Frequency Distribution of Call Codes, Six Samples

Code Description	Mar. 1970	Sept. 1971	Mar. 1972	Sept. 1972	Dec. 1972	Mar. 1973
Sample Size	2735	729	731	805	1681	899
33 - Fire	.0044	.0055	.0027	.0000	.0071	.0044
41 - Auto accident	.1364	.1413	.1259	.1478	.1267	.1402
46 - Person hit by auto	.0262	.0219	.0260	.0224	.0232	.0267
47 - Person injured	.0833	.1372	.0944	.1279	.1249	.1090
48 - Person dead	.0113	.0123	.0082	.0037	.0065	.0056
50 - Person shot	.0440	.0631	.0561	.0435	.0440	.0423
51 - Person stabbed	.0287	.0329	.0246	.0460	.0321	.0423
53 - Attempted suicide (Primarily drug overdoses)	.0160	.0247	.0246	.0224	.0256	.0211
62 - Obstetrics	.0375	.0315	.0479	.0385	.0369	.0467
67 - Person down	.4671	.4129	.4651	.4248	.4515	.4138
82 - Non-urgent	.1386	.1139	.1190	.1056	.1130	.1413
Other	.0065	.0027	.0055	.0174	.0083	.0067

Table 21. Frequency Distribution of Calls per Category, Six Samples (Emergency Calls only)

Category	Mar. 1970	Sept. 1971	Mar. 1972	Sept. 1972	Dec. 1972	Mar. 1973
Y_2 Drug intoxication	4.225	3.261	2.648	3.477	3.944	2.749
Y_3 OB/GYN	4.478	3.571	5.296	4.729	4.746	5.497
Y_8 Dry runs	26.109	25.466	22.429	26.147	23.195	27.879
Y_4 Auto related trauma	12.083	12.112	11.838	11.961	11.765	12.958
Y_5 Other trauma	22.095	28.261	25.857	26.565	25.401	26.439
Y_6 Cardio-vascular and pulmonary	9.675	9.317	12.305	10.570	12.032	10.079
Y_7 Other medical	21.335	18.012	19.626	16.551	18.917	14.398

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